B.Tech ECE(IoT)
Scheme
IIIT Nagpur
(2023 Batch Onwards)

IIIT Nagpur New Scheme for B.Tech ECE (IoT)

Year	Semester	Course Code	Course Name	Type	L	T	P	Credits
FIRST YEAR								
1	1	MAL 108	Applied Mathematics for Engineers	BS	3	1	0	4
1	1	ECL 110	Electronic Devices and Applications	DC	3	0	2	4
1	1	ECL 104	Introduction to IoT	DC	3	0	2	4
1	1	CSL 101	Computer Programming	DC	3	0	2	4
1	1	ECL 105	Electrical Systems	DC	3	0	2	4
1	1	HUL 102	Environmental studies	HU	2	0	0	2
1	1	SAP 101	Health, sports and safety	HU	0	0	2	0
Sub Total					**17**	**1**	**10**	**22**
1	2	ECL 106	Digital System Design with HDL	DC	3	0	2	4
1	2	CSL 102	Data Structures	DC	3	0	2	4
1	2	ECL 107	Analog IC and Fabrication	DC	3	0	2	4
1	2	ECP 101	IoT Workshop –I	DC	0	0	4	2
1	2	MAL 201	Numerical Methods and Probability Theory	BS	3	1	0	4
1	2	ECL 109	Instrumentation Techniques	DC	3	0	0	3
1	2	HUL 101	Communication skills	HU	2	0	2	3
Sub Total					**17**	**1**	**12**	**24**
Total					**34**	**2**	**22**	**46**
SECOND YEAR								
2	3	ECL 211	Applied Signals and Systems	DC	3	0	2	4
2	3	CSL 202	Introduction to Object Oriented Programming	DC	3	0	2	4
2	3	ECL 212	Sensors and Transducers	DC	3	0	2	4
2	3	ECP 201	IoT Workshop -II	DC	0	0	4	2
2	3	CSL 217	Programming Techniques for IoT	DC	2	0	2	3
2	3	ECL 213	Electromagnetic Field Theory	DC	3	0	0	3
Sub Total					**14**	**0**	**12**	**20**

2	4	ECL 214	DSP and Applications	DC	3	0	2	4
2	4	ECL 215	Modelling for IoT	DC	3	0	2	4
2	4	ECL 216	Microprocessor and Microcontroller	DC	3	0	2	4
2	4	ECL 217	Communication Systems	DC	3	0	2	4
2	4	CSL 301	Database Management System	DC	3	0	2	4
2	4	ECP 202	IoT Workshop- III	DC	0	0	4	2
Sub Total					**15**	**0**	**14**	**22**
Total					**29**	**0**	**26**	**42**

Year	Semester	Course Code	Course Name	Type	L	T	P	Credits
THIRD YEAR								
3	5	ECL 315	Communication Network	DC	3	0	2	4
3	5	ECL 308	Embedded Systems	DC	3	0	2	4
3	5		Departmental Elective -I	DE	3	0	0	3
3	5		Departmental Elective - II	DE	3	0	2	4
			Departmental Elective - III	DE	3	0	2	4
3	5		Open Course - I	OC	3	0	0	3
Sub Total					**18**	**0**	**8**	**22**
3	6	ECL 316	IoT Security	DC	3	0	0	3
3	6		Departmental Elective -IV	DE	3	0	2	4
3	6		Departmental Elective - V	DE	3	0	2	4
3	6		Fractal Course (DE) (1.1)	DE	1	0	0	1
3	6		Fractal Course (DE) (1.2)	DE	1	0	0	1
3	6		Fractal Course (DE) (1.3)	DE	1	0	0	1
		ECD 301	Minor Project	DC	0	0	6	3
			OC-II	OC	3	0	0	3
Sub Total					**15**	**0**	**10**	**20**
Total					**33**	**0**	**18**	**42**
FINAL YEAR								
4th	7th		OPEN / MOOC course	OC	3	0	0	3
4th	7th		Departmental Elective –VI	DE	3	0	0	3
4th	7th		Departmental Elective - VII	DE	3	0	0	3
4th	7th	ECD 406	Project	DE	0	0	16	8
OR								
4th	7th	ECD 407	Internship	DE	0	0	16	8
Sub Total					**9**	**0**	**16**	**17/8**

4th	8th	ECD 407	Internship	DE	0	0	16	8
OR								
4th	8th	ECD 406/ ECD 407	Project/ Internship-II	DE	0	0	16	8
4th	8th		OPEN / MOOC course	OC	3	0	0	3
4th	8th		Departmental Elective –VI	DE	3	0	0	3
4th	8th		Departmental Elective - VII	DE	3	0	0	3
Sub Total					**9**	**0**	**16**	**17/8**
Total								**25**
GRAND TOTAL								**155**

Sem	Credits
1	**22**
2	**24**
3	**20**
4	**22**
5	**22**
6	**20**
7&8	**17/8**
TOTAL	**155**

Type	Credits
BS	**08**
HU	**05**
OC	**09**
DC	**89**
DE	**44**
TOTAL	**155**

(2023 Batch Onwards)

B.Tech

ECE(IoT) Syllabus

Core Courses

IIIT Nagpur

First Year

Year and Semester: First Year, First Semester
Course Title: Applied Mathematics for Engineers (MAL 108)

Course Code	MAL 108	**Course Title**	Applied Mathematics for Engineers			
Category	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	1	0	4
Pre-requisite (If any)	Nil	**Type of Course**	Basic Science			

Course Outcomes:

1. Application of line, surface, and volume integrals.
2. Apply the concepts of matrices for solving system of linear equations.
3. Solve first-order linear/nonlinear ordinary differential equations analytically using standard methods.
4. Demonstrate various models through higher order differential equations and solve such linear ordinary differential equations.
5. Analytical Solution of partial differential equations.

Course Contents:

Module I:
Vector Calculus: Scalar and vector fields, coordinate system- Cartesian, spherical, Cylindrical gradient of scalar point function, directional derivatives, divergence and curl of vector point function, solenoidal and irrotationalmotion.Vector integration: line, surface and volume integrals, Green‟s theorem, Stoke's theorem and Gauss divergence theorem (without proof).

Module II:
Matrices: Rank of matrix, consistency of a system of equations, linear dependence and independence, linear and orthogonal transformations, Eigen values and eigen vectors, Cayley – Hamilton theorem, reduction to diagonal form, Hermitian and skew Hermitian matrices, Quadratic forms.

Module III:
Ordinary Differential Equations: First order differential equations: Exact equation,Integrating factors, Reducible to exact differential equations, Linear and Bernoulli's form,orthogonal trajectories, Existence and Uniqueness of solutions. Solutions of second and higher order linear equation with constant coefficients, Linear independence and dependence, Method of variation of parameters, Solution of Cauchy's equation, simultaneous linear equations.

Module IV:
Partial Differential Equations: Origin of first-order partial differential equations, Cauchy's problem, Linear equations, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear partial differential equations of the first-order, Cauchy's method of characteristics, Compatible systems of first-order equations, Charpit's method, Jacobi's method, Linear

partial differential equations, Characteristic curves, Separations of variables, Integral transform method for parabolic, hyperbolic and elliptic equations.

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th Edition, Khanna Publishers, 2018.
2. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition (Reprint), John Wiley & Sons.
3. V. Ramana, Higher Engineering Mathematics, 11th Edition, McGraw-Hill Education.

Reference Books:

1. Srimanta Pal & Subodh C. Bhunia, Engineering Mathematics, Oxford University Press, 3rd Reprint, 2016.
2. N. P. Bali & Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications, Latest Edition.
3. C. Ray Wylie & Louis C. Barrett, Advanced Engineering Mathematics, McGraw-Hill Book Co., New York, Latest Edition.
4. C. B. Gupta, S. R. Singh & Mukesh Kumar, Engineering Mathematics for Semester I and II, McGraw-Hill Education (India) Pvt. Ltd., 2015.
5. H. K. Dass & Er. Rajnish Verma, Higher Engineering Mathematics, S. Chand Publications, 2014.

Year and Semester: First Year, First Semester
Course Title: Electronics Devices and Applications (ECL 110)

Course Code:	ECL 110	**Course Title:**	Electronics Devices and Applications			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. To Relate and apply fundamentals of semiconductor devices, such as diode, BJT, LED, MOSFET into various practical applications.
2. To understand the implementation of linear and non – linear analog block implementation and their testing.
3. To understand the Frequency response, stability and noise issues in amplifiers.
4. To apply concepts of basic electronic devices into electronic circuits and can analyze various parameters.
5. Design and analyse basic electronic circuits.

Course Contents:

Module I:
P & N Type Semiconductors, Diodes and Power Supplies, Theory of P-N Junction Diode, Junction Capacitance, Halfwave & Fullwave, Rectifiers, Filters, Ripple-Factor, Characteristics & Applications of Following Diodes, Zener as Regulators, Schottkey, Photodiode, LED, LCD, Varactor Diode &Tunnel Diode.

Module II:
Junction Transistors Theory of Operation, Static Characteristics , Break Down Voltages, Current Voltage Power Limitations, Biasing of BJT Different Biasing Arrangements, Stability Factor, Thermal Runaway, Power Transistors.

Module III:
Small Signal Analysis & High Frequency Analysis of BJT CE, CB, CC Amplifiers and Comparison High Frequency Analysis Calculation of Frequency Response, Gain Bandwidth Product. Power Amplifiers Classification A, B, AB, C Classes, Efficiency, Push Pull Configuration, Complimentary Symmetry, Second Harmonic & Cross Over Distortion.

Module IV:
Positive and Negative Feedback Amplifiers Classification, Practical Circuits, Applications, Advantages. Oscillators Stability, Barkhausen Criteria, RC, LC & Crystal Oscillators.

Module V:
Field Effect Transistor & MOSFET, Principle of Operation & Characteristics.

Text Books:

1. J. Millman and C. C. Halkias, Integrated Electronics, 2nd Ed., McGraw-Hill, 2011.
2. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 10th Ed., Pearson, 2011.

Reference Books:

1. J. Millman and C. C. Halkias, Electronic Devices and Circuits, 2nd Ed., McGraw-Hill Education, 2011.
2. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits, 2nd Ed., McGraw-Hill, 1998.
3. J. M. Fiore, Op Amps and Linear Integrated Circuits: Concepts and Applications, 1st Ed., Cengage Learning, 2010.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Study of Cathode Ray Oscilloscope and Function wave generator and familiarization with basic electronic components.
2. Study and verify Ohm's Law.
3. Study of Volt-Ampere Characteristics of diode.
4. Study of Half-Wave rectifier circuit with and without filter.
5. Study of Full-Wave rectifier circuit with and without filter.
6. Study of Clipper Circuit.
7. Study of Clamper Circuit.
8. Study of Volt-Ampere Characteristics of Zener Diode and use of Zener diode as a Voltage regulator circuit.
9. Study the input and output characteristics of a bipolar Junction Transistor (BJT).
10. Study of Bipolar Junction Transistor as a common emitter amplifier.

	Program Outcomes											
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	0	0	0	2	1	0	2
CO2	3	3	2	3	3	0	0	0	2	2	1	2
CO3	3	3	3	3	3	0	0	0	2	2	1	2
CO4	3	2	2	2	2	0	0	0	2	0	0	2
CO5	3	3	3	3	3	0	0	0	2	2	1	2

Year and Semester: First Year, First Semester
Course Title: Introduction to IoT (ECL 104)

<table>
<tr><td>Course Code:</td><td>ECL 104</td><td>Course Title:</td><td colspan="4">Introduction to IoT</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Nil</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
<tr><td colspan="7">Course Outcomes:

1. Conceptualize interaction of IoT device with the physical world environment.
2. Understand individual components of IoT systems.
3. Build a system with sensors and actuators using Arduino.
4. To conceptualize the sensor node for capturing data from the physical world.
5. To conceptualize complete IoT systems using components of IoT system.</td></tr>
<tr><td colspan="7">Course Contents:

Module I:
Introduction to IoT, Sensing, Actuation, Basics of IoT Networking, Connectivity Technologies.

Module II:
Sensor Networks, UAV networks, Machine-to-Machine Communications Interoperability in IoT.

Module III:
Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Raspberry Pi and programming, Implementation of IoT with Raspberry Pi Introduction to SDN, SDN for IoT.

Module IV:
Data Handling and Analytics, Cloud Computing, and Fog Computing, Introduction to Industrial IoT.

Module V:
Case Studies: Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Agriculture, Healthcare, Activity Monitoring.</td></tr>
<tr><td colspan="7">Text Books:
1. A. Bahga and V. Madisetti, Internet of Things: A Hands-on Approach, 1st Ed., Universities Press, 2015.
2. S. Monk, Raspberry Pi Cookbook: Software and Hardware Problems and Solutions, 2nd Ed., O'Reilly Media, 2016.</td></tr>
</table>

Reference books:

1. P. Waher, Learning Internet of Things, Packt Publishing, 2015.
2. O. Vermesan and P. Friess, Eds., Internet of Things – From Research and Innovation to Market Deployment, River Publishers, 2014.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Introduction to Arduino IDE and Arduino programming and to blink an LED using Arduino UNO.
2. To interface temperature and humidity sensor (DHT11) with Arduino UNO and write a program to read the data and display on serial monitor.
3. To interface Seven Segment Display (SSD) with Arduino UNO and write a program to display numbers on it.
4. To interface button with Arduino UNO and write a program to count the number of times button was pressed & display its value on SSD.
5. To interface light dependent resistor (LDR) with Arduino UNO and write a program to turn ON/OFF an indicator upon dark detection.
6. To interface Ultrasonic sensor (HC-SR04) with Arduino UNO and write a program for distance measurement.
7. To interface gas sensor (MQ-2) with Arduino UNO and write a program for gas detection.
8. To interface remote controller with Arduino UNO and write a program to control LEDs from remote.
9. To interface 16×2 LCD with Arduino UNO and write a program display numbers and/or text on it.
10. To make a mini weather station from Arduino UNO board, LDR, 16×2 LCD, and DHT11 sensor.
11. Group project.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	1	2	2	1	1	0	2	1
CO2	3	3	2	2	2	1	1	1	1	0	2	1
CO3	2	3	3	3	3	1	1	2	2	1	2	2
CO4	3	3	2	2	2	1	1	1	1	0	2	1
CO5	3	3	3	3	3	2	2	2	2	1	3	3

Year and Semester: First Year, First Semester
Course Title: Computer Programming (CSL 101)

Course Code:	CSL 101	**Course Title:**	Computer Programming			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Computer Science Engineering			

Course Outcomes:

1. Appreciation and practice of structured programming
2. Ability to formulate the problem, devise an algorithm and transform into code
3. Understanding different programing techniques and make an informed choice amongst them
4. Understanding different sorting algorithms, their advantages and disadvantages,
5. Appreciation of concept of dynamic memory allocation and its utilization, dynamic data structures and implementation
6. Understanding of concept of Abstract Data Type and implementations.

Course Contents:

Module I:
Types and operations, Iterative constructs and loop invariants, Quantifiers and loops, structured programming and modular design, Illustrative examples, Scope rules, parameter passing mechanisms, recursion, program stack and function invocations including recursion

Module II:
Overview of arrays and array based algorithms - searching and sorting, Mergesort, Quicksort, Binary search, Introduction to Program complexity (Big Oh notation), Sparse matrices.

Module III:
Structures (Records) and array of structures (records). Database implementation using array of records. Dynamic memory allocation and deallocation. Dynamically allocated single and multi-dimensional arrays.

Module IV:
Concept of an Abstract Data Type (ADT), Lists as dynamic structures, operations on lists, implementation of linked list using arrays and its operations. Introduction to linked list implementation using self-referential-structures/pointers.

Module V:
Stack, Queues and its operations. Implementation of stacks and queues using both array-based and pointer-based structures. Uses of stacks in simulating recursive
procedures functions. Applications of stacks and queues.

Module VI:
Lists - Singly-linked lists, doubly linked lists and circular linked lists. List traversal, insertion, deletion at different positions in the linked lists, concatenation, list-reversal etc. Merge sort

Text Books:

1. R. Kruse, G. L. Tondo, and B. Leung, Data Structures and Program Design in C, PHI Learning.
2. E. Horowitz, S. Sahni, and S. Anderson-Freed, Fundamentals of Data Structures in C, 2nd ed., University Press.

Reference Books:

1. A. V. Aho, J. E. Hopcroft, and J. D. Ullman, Data Structures and Algorithms, Reading, MA: Addison-Wesley, 1983.

List of Experiments:

1. Implementation of Binary search, Quick Sort, Merge Sort
2. Implementation of linked lists, insertion, deletion, finding an element.
3. Implementation of Sparse matrices, ADT and its Operation.4) Implementation of Queue and its operations.
4. Implementation of Stacks and its operation.
5. Implementation of Priority Queues and its operations.

Year and Semester: First Year, First Semester
Course Title: Electrical Systems (ECL 105)

<table>
<tr><td>Course Code:</td><td>ECL 105</td><td>Course Title:</td><td colspan="4">Electrical Systems</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Nil</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. Demonstrate application of fundamental laws to analyze dc electric and magnetic circuits
2. Apply fundamental laws and phasor method to analyze ac circuits
3. Illustrate working principle, equations and determine transformer parameters, regulation and efficiency
4. Demonstrate working principle, equations and application of dc machines and induction motor
5. Demonstrate principle of basic protection and power electronic circuits

Course Contents:

Module I:
Electrical Circuit: Circuit Elements Resistance, Inductance & Capacitance, Series, Parallel circuits, Star-Delta Transformation , Voltage, Current, Power, Energy , Voltage Source, Current Source, Practical Source, Voltage Division , Current Division, Kirchhoff's Laws Current and Voltage, source transformation, Mesh Analysis, Nodal Analysis, Super Mesh, Super Node, Superposition Theorem, Magnetic Circuit, Flux, MMF, Reluctance, Analogy with Electric Circuits, BH Curve Simple Calculations for Composite Magnetic Circuits

Module II:
AC Circuits: Periodic Function, Average & R.M.S., Values, Steady State Behavior With Sinusoidal Excitation, Phasor Representation, Reactance & Impedance, Series & Parallel Circuit, Power Factor, Principle of Generation of Single Phase & Three Phase Voltages,Star-Delta Transformation , Voltage Division , Current Division, Kirchhoff's Laws Current and Voltage, Source transformation, Mesh Analysis, Nodal Analysis, Super Mesh, Super Node, Superposition Theorem, Three Phase Balanced Circuits, Three Phase Load, Star Connection, Delta Connection, Voltage and Current Relationship in Three Phase Systems Star and Delta, Power in Balanced Three Phase AC System

Module III:
Transformers : Introduction, Basic Principles, Construction, Phasor Diagram for Transformer under No Load Condition Transformer On Load, Balance of MMF on Sides, Phasor Diagram, Equivalent Circuit, Open Circuit & Short Circuit Test, Voltage Regulation and Efficiency

Module IV:
Electric Machines :DC Shunt and Series Motor – Construction, Principle of Working, Characteristics, Speed Control and Applications

Induction Motors – Construction, Principle of Working of Single Phase and 3-Phase Motors. Torque Slip Characteristics

Module V:
Basics of protection – fuse, relay principles types, introduction to power electronic conversion principles, basic converters, inverters, introduction to power systems, renewable energy systems, and electric vehicles.

Text Books/Reference Books:

1. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 4th Ed., Tata McGraw-Hill Education, 2019.
2. D. C. Kulshreshtha, Basic Electrical Engineering, 2nd Ed., McGraw-Hill Education Pvt. Ltd., 2019.

Reference Books:

1. E. Hughes, Electrical and Electronics Technology, 10th Ed., Pearson Education Limited, 2008.
2. V. Deltoro, Electrical Engineering Fundamentals, 2nd Ed., Prentice Hall India, 1989.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. To verify Kirchoff's voltage law (KVL) and Kirchoff's current law (KCL) in DC circuits (resistive circuit).
2. To verify superposition theorem
3. To determine resonant frequency of series and parallel RLC circuit
4. To measure single phase power by voltmeter and ammeter methods
5. To measure three phase power by two wattmeter method
6. To perform open circuit and short circuit tests on single phase transformer
7. To determine torque speed characteristics of DC shunt motor
8. To find torque slip characteristics of induction motor
9. Study of speed control of DC motor by field current and armature control
10. Study of reversal of direction of rotation of three phase induction motor

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	1	2	0	0	1	1	0	2
CO2	3	2	2	2	1	2	0	0	1	1	0	2
CO3	3	3	3	2	2	2	1	0	1	2	1	2
CO4	3	3	3	3	3	2	1	0	2	2	2	2
CO5	3	3	3	3	3	2	1	0	2	2	2	2

Year and Semester: First Year, First Semester
Course Title: Environmental Studies (HUL 102)

Course Code:	HUL 102	**Course Title:**	Environmental Studies			
Category:	HU	**Credit Assigned**	L	T	P	C
			2	0	0	2
Pre-Requisite (if Any)	Nil	**Type of Course**	Basic Science			

Course Outcomes:

1. Introduction to various natural resources, their importance and status.
2. Introduction to the concepts of ecosystem, their structure and functions.
3. Introduction to the concept of biodiversity conservation.
4. Introduction to possible causes of various forms of environmental pollution and their consequences, methods of prevention.
5. Introduction to various social and climatic changes due to pollution.

Course Contents:

Module I:
Natural resources: Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources.

Module II:
Ecosystem: Concept of an ecosystem, Structure and functions of an ecosystem, Producers, consumers and decomposers, Ecological succession, Food chain, food webs and pyramids.
Biodiversity and its conservation: Introduction, definitions: genetics, species and diversity, Value of biodiversity, Biodiversity at global, national and local level, India as a mega-diversity nation, Hot-spot of biodiversity, Threat to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Conservation of biodiversity: in-situ and ex-situ conservation.

Module III:
Environmental pollution: Definition, Causes, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards, Solid waste management: Causes, effects and control measures of urban and industrial wastes.

Module IV:
Social issues and environment: Sustainable development, Water conservation, Rain water harvesting, Watershed management, Climate change, Global warming, Acid rain, Ozone layer depletion, Nuclear accident, Holocaust, Environmental rules and regulations.

Module V:
Human population and environment: Population growth, Environment and human health, Human rights, Value education, Role of information technology in environment and human health.

Text Books:

1. Rajagopalan, Environmental Studies: From Crisis to Cure, 3rd edition, Oxford University Press, 2015.

Reference Books:

1. Benny Joseph, Environmental Studies, McGraw Hill.
2. Erach Barucha, Environmental Studies, University Press (UGC).

Year and Semester: First Year, First Semester.
Course Title: Health, Sports and Safety (SAP 101)

Course Code:	SAP 101	**Course Title:**	Health, Sports & Safety			
Category:	Core	**Credit Assigned**	L	T	P	C
			0	0	2	0
Pre-Requisite (if Any)	Nil	**Type of Course**	Audit			

Course Outcomes:

1. To provide physical fitness and good health.
2. Create awareness among the students about their health status by conducting various tests and measurements and suggest them suitable remedial physical fitness program so that they can improve physical health status.
3. Improve physiological health status.
4. To improve productivity, foster social harmony, inculcate sense of discipline and dedication in general life.
5. Develop the spirit of teamwork, through various sports activities.

Course Contents:

Module I:
Development of components of fitness through conditioning exercises:
Strength: (Strength Endurance, Maximum Strength, explosive strength), Endurance: (aerobic endurance, anaerobic endurance, speed endurance and strength endurance), Speed, Co-coordinative ability, Flexibility

Module II:
Physical Efficiency Test Level 1 (Testing and Evaluation of Physical Fitness):
Cooper Test 12 minute run or walk test, Sit and reach test, 100 meter run, one minute sit up test, Push up/Bent knee push up test,

Module III:
Teaching and development of sports skills: Cognitive, Perceptual, Motor, Perceptual motor.

Module IV:
First Aid training
Intramural phase 1: Identification of sports talent through exposing students to inter-section tournament. Football, Volleyball, throw ball, table tennis & Chess.

Module V:
Yoga, Meditation and Personal Safety.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1) Physical Efficiency Test(Testing and Evaluation of Physical Fitness):1500 meter run, shuttle run, standing broad jump, one minute sit up test, flexibility test

Testing and assessment of selected Physiological parameters through Sports Medicine Research Lab: Total body fat analysis, Harvard step test, BMI, WHR, Back strength, Leg strength, grip strength, resting pulse rate, and resting respiratory rate.
Intramural phase 2: Badminton, Basketball, Cricket, Kho-Kho, etc.
Yoga and Meditation.

2)Personal Safety Skill Demonstration

Year and Semester: First Year, Second Semester
Course Title: Digital System Design with HDL (ECL 106)

<table>
<tr><td>Course Code:</td><td>ECL 106</td><td>Course Title:</td><td colspan="4">Digital System Design with HDL</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Electronic Devices and Applications</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

On successful completion of the course, students will be able to:

1. Represent a digital system using basic digital blocks.
2. Apply Boolean Algebra in digital circuit design.
3. Illustrate and design various building blocks of combinational and sequential circuits.
4. Design and describe digital systems at different levels of abstraction.
5. Develop reusable and synthesizable RTL code.

Course Contents:

Module I:

Introduction to digital Systems, Number systems and conversion, Signed and unsigned numbers, Complements, Binary codes. Boolean algebra, Boolean functions- Truth table, Logic gates, Canonical and standard forms, Simplification of functions using Karnaugh map – Minimization of SoP and PoS forms.

Module II:

Combinational circuits - Arithmetic circuits (Half adder/subtractor, Full adder/subtractor), Code converters, Magnitude comparators, Decoders and encoders, Multiplexers and demultiplexers.

Module III:

Sequential circuits - Latches and flip flops (RS, JK, D, T and Master Slave), Counters- Asynchronous counters, Synchronous counters, Shift registers, Finite state machines.

Module IV:

Introduction to Hardware Description Languages (HDL), VLSI design flow - Verilog syntax, data types, and operators – Modules, ports, and vector representation, Structural and dataflow modeling, hierarchical design, testbenches with practical examples, Delay modeling concepts.

Module V:

Behavioral modeling concepts, procedural statements, and timing control – Blocking and non-blocking assignments – Combinational and sequential circuit modeling, Finite State Machine (FSM) modeling.

Text Books:

1. M. Mano and M. D. Ciletti, Digital Design, 4th Ed., Pearson Prentice-Hall, 2006.

2. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, 2nd Ed., Prentice Hall, 2003.

Reference Books:

1. D. E. Thomas and P. R. Moorby, The Verilog Hardware Description Language, 2nd Ed., Kluwer Academic Publishers, 2002.
2. T. L. Floyd, Digital Fundamentals, 10th Ed., Prentice Hall, 2009.
3. S. D. Brown and Z. G. Vranesic, Fundamentals of Digital Logic with Verilog Design, 3rd Ed., McGraw-Hill, 2014.
4. C. H. Roth Jr., L. L. Kinney, and E. B. John, Fundamentals of Logic Design, 6th Ed., Cengage Learning, 2020.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Study of basic components and ICs used in digital electronics lab.
2. Implementation of basic logic gates using switches, p-n junction diodes and bipolar junction transistor.
3. Study of universal gates and implementation of Boolean functions using NAND and NOR gates.
4. Implementation of 1-bit Full Adder/Subtractor using logic gates.
5. Realization of Adder and Subtractor circuits using Multiplexer.
6. Study of sequential circuits and implementation of Flip-Flops.
7. Familiarization with the Vivado IDE, creating a new project, writing a simple Verilog module, simulating, and generating the waveform.
8. Design and simulate basic combinational circuit(Basic gates, HA, FA).
9. Understand data selection and distribution using multiplexers and demultiplexers.
10. Understand and implement different flip-flops.
11. Implement different types of counters.
12. Design and simulate different shift registers.
13. Model sequential circuits using FSMs.
14. Design a simple Arithmetic Logic Unit (ALU) that performs arithmetic and logical operations.
15. Implementation on FPGA Board.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	3	0	0	0	1	1	0	2
CO2	3	3	2	1	2	0	0	0	1	1	0	2
CO3	3	3	3	2	3	0	0	0	1	1	0	2
CO4	3	2	3	2	3	0	0	0	1	1	0	2
CO5	3	2	3	2	3	0	0	0	1	1	0	2

Year and Semester: First Year, Second Semester
Course Title: Data Structures (CSL 102)

Course Code:	CSL 102	**Course Title:**	Data Structures			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Programming Fundamentals (CSL 112)	**Type of Course**	Computer Science and Engineering			

Course Outcomes:

1. Appreciation and practice of structured programming
2. Ability to formulate the problem, devise an algorithm and transform into code
3. Understanding different programing techniques and make an informed choice amongst them
4. Understanding different sorting algorithms, their advantages and disadvantages,
5. Appreciation of concept of dynamic memory allocation and its utilization, dynamic data structures and implementation. Understanding of concept of Abstract Data Type and implementations.

Course Contents:

Module I:
Basics of data structures, Definition of Data Structures, Abstract Data Types, Usage, Types of Data Structures. List: Linked Representation, Singly Linked Lists Operations-Insertion, Deletion, Circular linked lists-Operations on Circular linked lists, Doubly Linked Lists- Insertion,Deletion.

Module II:
Stacks: Definition, Linked Implementations, Recursion Implementation, Queue: ADT, Definition, Array And Linked Implementations, Circular Queues-Insertion And Deletion Operations

Module III:
Trees – definition, terminology, Properties of Binary Trees, Binary search tree. Searching, Insertion, Deletion, finding the height of BST, Iterative Tree Traversals, Recursive Tree Traversal. Evaluation and conversations of Expressions-Infix, prefix, and postfix.

Module IV:
Priority Queues –Definition and applications, Max Priority Queue ADT-implementation-Max Heap-Definition, Insertion into a Max Heap, Deletion from a Max Heap, Sorting techniques

Module V:
Graphs–Graph ADT, Graph Representations- Adjacency matrix, Adjacency lists, Graph Search methods - DFS and BFS.

Text Books:

1. Langsam, Y., Augenstein, M. J., & Tanenbaum, A. M., Data Structures Using C and C++, Prentice Hall India Learning Private Limited, 2nd Edition.
2. Seymour Lipschutz, Data Structures, Schaum's Outlines Series.

3. Ellis Horowitz & Sartaj Sahni, Fundamentals of Data Structures in C, Universities Press, 2nd Edition.

Reference Books:

1. Narasimha Karumanchi, Data Structures and Algorithms Made Easy, CareerMonk Publications, 2nd Edition.
2. Adam Drozdek, Data Structures and Algorithms in C++, Course Technology, 3rd Edition.
3. Mark A. Weiss, Data Structures & Algorithm Analysis in C++, Pearson, 4th Edition.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Operations on Linked Lists 2. Operations on Linked Lists with Header node
2. Programs on Implementations of Stacks and Queues 4. Applications of Stacks and Queues
3. Binary Tree Traversals (Recursive and Iterative) 6. Operations on Search Trees
4. Evaluation and conversations of Expressions 8. Graph creation and representation
5. DFS and BFS Sorting techniques

Year and Semester: First Year, Second Semester
Course Title: Analog IC and Fabrication (ECL 107)

<table>
<tr><td>Course Code:</td><td>ECL 107</td><td>Course Title:</td><td colspan="4">Analog IC and Fabrication</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Electronic Devices and Applications</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. Through the course, students are able to understand the Basics of analog IC design.
2. To understand the Frequency response, stability and noise issues in amplifiers.
3. To understand the implementation of linear and non – linear analog block implementation and their testing.
4. Demonstrate the use of analog circuit analysis to analyze the operation and behavior of various modern analog integrated circuits.
5. Attain a comprehensive understanding of the fundamentals of the IC fabrication process.

Course Contents:

Module I:
Differential amplifier, configurations, DC & AC analysis, constant current bias, current mirror, cascaded differential amplifier stages, level translator.

Module II:
OPAMP: Basics, inverting and non inverting, differential amplifier configuration, negative feedback, voltage gain, input & output impedance, Bandwidth. Input offset voltage, input bias and offset current, Thermal drift, CMRR, PSRR, Frequency response.

Module III:
Linear applications, DC, ac amplifiers, summing differential amplifier, instrumentation amplifier, V to I and I to V converters, Integrator, Differentiator. Nonlinear applications, Comparators, Schmitt Trigger, Clipping and Clamping circuits, Absolute value circuits, Peak detectors, Sample and hold circuits, Log and antilog amplifiers.

Module IV:
First / Second order low/ high/ bandpass, band reject active filters, All pass filter, phase shift oscillator, Wein bridge oscillator, Square wave and triangular waveform generators.

Module V:
Introduction to IC Technology, IC fabrication process flow, Crystal Growth and Wafer preparation, introduction to oxidation, diffusion and ion implantation, thin film deposition and growth, etching and cleaning, photolithography, metallization, packaging.

Text Books:

1. J. G. Graeme, G. E. Tobey, and L. P. Huelsman, Operational Amplifiers: Design and Applications, 1st Ed., McGraw-Hill, 1971.
2. R. A. Gaikwad, Operational Amplifiers and Linear Integrated Circuits, 4th Ed., Pearson Education, 2015.

Reference Books:

1. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits, 2nd Ed., McGraw-Hill, 1998.
2. J. M. Fiore, Op Amps and Linear Integrated Circuits: Concepts and Applications, 1st Ed., Cengage Learning, 2010.
3. F. S. Fransis, Design with OPAMPs and Analog ICs, 2nd Ed., McGraw-Hill, 1998.
4. J. M. Fiore, OPAMPs and Linear ICs, Delmar-Thomson Learning, USA, 2001.
5. J. Y. Chen, CMOS Devices and Technology for VLSI, 1st Ed., Prentice Hall, 1990.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Introduction to Operational Amplifier (op-amp) and measure various op amp parameters.
2. To design an Inverting Amplifier for the given specifications using Op-Amp IC 741
3. To design a Non-Inverting Amplifier for the given specifications using Op-Amp IC 741.
4. To design an Integrator circuit for the given specifications using Op-Amp IC 741.
5. To design and setup a zero crossing detector circuit with OP AMP 741C and plot the waveforms.
6. To design and setup a summing amplifier circuit with OP-AMP 741C for a gain of 2 and verify the output.
7. To construct and study the behavior of logarithmic and antilogarithmic amplifier.
8. To design and setup a Schmitt trigger, plot the input output waveforms and measure VUT and VLT.
9. To design and obtain the frequency response of second order Low Pass Filter (LPF).
10. To design and setup symmetrical and asymmetrical astable multivibrators using op-amp 741, plot the waveforms and measure the frequency of oscillation.
11. To design and setup a monostable multivibrator using Op-amp 741 and (i) Plot the waveforms (ii) Measure the time delay.
12. To Design and setup a RC phase shift oscillator using Op-Amp 741 and (i) Plot the output waveform (ii) Measure the frequency of oscillation.
13. To Design and setup a square wave and triangular wave generators using Op-Amp 741 and plot the output waveforms.
14. To design and setup symmetrical and asymmetrical astable multivibrators using IC 555 and (i) Plot the output waveform (ii) Measure the frequency of oscillation.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	2	0	0	0	0	1	0	2
CO2	3	3	2	2	3	0	0	0	0	0	0	2
CO3	3	2	3	2	3	0	0	0	0	0	1	2
CO4	3	3	2	3	3	0	0	0	0	1	0	2
CO5	2	2	1	1	1	1	1	0	0	0	0	2

Year and Semester: First Year, Second Semester
Course Title: IoT Workshop-I (ECP 101)

Course Code:	ECP 101	**Course Title:**	IoT Workshop-I			
Category:	Core (DC)	**Credit Assigned**	L	T	P	C
			0	0	4	2
Pre-Requisite (if Any)	Electronic Devices and Applications (ECL 103)	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Examine the working principle of basic electronic systems.
2. To conceptualize simulation of IoT systems.
3. Model a physical component for the IoT system.
4. Design an IoT system using components for the IoT.
5. Troubleshoot the connectivity among the components of IoT.

Curriculum:

The students will be exposed to ESP 32 and group projects will be allotted from time to time. A total of 4 projects/group will be assigned to evaluate the students.

The sample list of Projects:

1. Connection of two HC-SR04 sensors and display their average value on Seven Segment Display (SSD).
2. Connection of three HC-SR04 sensors and display their mean value on 16x2 LCD.
3. Connection of DHT 11 sensor, HC-SR-4, and 16x2 LCD and display a rolling message of the sensor data.
4. Connection of different sensors with ESP-32 and display the data on multiple SSDs.
5. Interface Blynk app with ESP 32 system and display and control the sensor readings via the App.
6. Whatsapp/Telegram integration of the ESP-32 system and display the sensor value on Whatsapp/Telegram.
7. Wireless connection between two ESP-32 systems, one ESP-32 will have sensor and will act as transmitter whereas the other ESP-32 will act as the receiver and will display the data on LCD.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	2	1	1	0	0	2	1	0	2
CO2	3	3	1	2	2	0	1	0	2	1	0	2
CO3	3	3	3	2	3	2	2	1	2	2	1	2
CO4	3	3	3	2	3	2	1	1	3	2	1	2
CO5	3	3	2	3	3	2	1	0	2	2	2	2

Year and Semester: First Year, Second Semester
Course Title: Numerical Methods and Probability Theory (MAL 201)

<table>
<tr><td>Course Code:</td><td>MAL 201</td><td>Course Title:</td><td colspan="4">Numerical Methods and Probability Theory</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td></td><td>Type of Course</td><td colspan="4">Basic Science</td></tr>
</table>

Course Outcomes:

1. To understand common numerical methods and how they are used to obtain approximate solutions of mathematical problems.
2. To analyze and evaluate the error and accuracy of common numerical methods.
3. To apply numerical methods to obtain approximate solutions to mathematical problems.
4. To understand concepts of probability, conditional probability and independence, random variables and probability distributions.
5. Application of random processes, autocorrelation and cross-correlation in the field of electronics and communication engineering

Course Contents:

Numerical Analysis: Solutions of algebraic and transcendental equations by Iteration method, method of false position, Newton-Raphson method and their convergence. Solutions of system of linear equations by Gauss elimination method, Gauss Seidal method, LU decomposition method. Newton-Raphson method for system of nonlinear equations. Eigen values and eigen vectors: Power and Jacobi methods. Numerical solution of ordinary differential equations: Taylor's series method, Euler's modified method, Runge-Kutta method, Adam's Bashforth and Adam's Moulton, Milne's predictor corrector method. Boundary value problems: Shooting method, finite difference methods.

Probability theory: Random variables, discrete and continuous random variable, probability density function; probability distribution function for discrete and continuous random variable joint distributions. Definition of mathematical expectation, functions of random variables, The variance and standard deviations, moment generating function other measures of central tendency and dispersion, Skewness and Kurtosis. Binomial, Geometric distribution, Poisson distribution, Relation between Binomial and Poisson's distribution, Normal distribution, Relation between Binomial and Normal distribution.
Random processes, continuous and discrete, determinism, stationarity, ergodicity etc. correlation functions, autocorrelation and cross-correlation, properties and applications of correlation functions.

Text Books:

1. Jain, Iyengar, and Jain, Numerical Methods for Engineers and Scientists, Wiley Eastern.

Reference Books:

1. V. K. Rohatgi and A. K. M. Ehsanes Sateh, An Introduction to Probability and Statistics, John Wiley & Sons.
2. S. D. Conte and C. de Boor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw-Hill.
3. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Addison-Wesley.
4. M. R. Spiegel, Theory and Problems of Probability and Statistics, McGraw-Hill, 1980.
5. K. S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, Prentice Hall of India Pvt. Ltd.

Year and Semester: First Year, Second Semester
Course Title: Instrumentation Techniques (ECL 109)

Course Code:	ECL 109	**Course Title:**	Instrumentation Techniques			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	0	3
Pre-Requisite (if Any)	Electrical Systems (ECL 105)	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Examine the working principle of basic electronic instruments.
2. Measure various electrical quantities with desired accuracy, precision and resolution
3. Mathematically model and analyse an electronic instrument.
4. Design an instrument as per the requirements of measurand.
5. Demonstrate ability to select suitable instruments for measurement of physical quantity

Course Contents:

Module I:
Accuracy and precision, Significant figures, Types of errors, statistical, Probability of errors, Limiting errors. Functional elements of an instrument, Active and Passive transducers, Analog and Digital mode of operation, Null deflection methods, Input and output configuration of measuring instrument and instrument system.

Module II:
Electromechanical Indicating Instruments: PMMC galvanometer, DC ammeters, DC voltmeter, series & shunt type ohmmeters, multi-meter, electrodynamometer for power measurement, power factor meter, instrumentation transformer.

Module III:
Bridge Measurements: Wheat stone bridge: Basic operation, measurement errors, Thevenin's equivalent circuit, Guarded Wheat-stone bridge, Kelvin bridge: Effects of connecting leads, Kelvin double Bridge. AC Bridges and their application: Condition and application of the balance equation. Maxwell's bridge, Hay Bridge, Schering Bridge, Wein Bridge unbalanced condition. Electronic Instruments: Amplified DC meter, AC voltmeter, electronic multimeter, digital voltmeter, Q meter

Module IV:
Transducers as input elements to the instrumentation system. Basic methods of force measurement, torque measurement, pressure and sound measurement. Temperature measurement: Standards and calibration, thermal expansion methods, thermocouples, resistance thermometers junction semiconductors sensors, digital thermometers. Strain Measurement: Bonded and un-bonded electrical strain gauges, gauge factor, temperature compensation methods. Biomedical sensors used for measurement of biological, chemical and physical process of human body.

Module V:
Oscilloscope: Introduction, Oscilloscope block Diagram, Cathode Ray tube (CRT), CRT circuits, Deflection systems, Delay line. Multiple trace, Simple frequency counters. Strip XY recorder, CRO.

LED display, LCD display, DSO. Signal conditioning Techniques used in various transducers, Gain clipping, filtering, amplification, data logger. IEEE 488 Bus: Principles of operation, protocols.

Text Books:

1. A. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation & Measurement Techniques. Prentice Hall of India, 2008.
2. E.O Doeblin, Measurements System: Application and Design, 4th Ed. New York, McGraw-Hill, 1990.

Reference Books:

1. F. E. Terman, Electronic Instrumentation, McGraw-Hill, 1990.
2. B. M. Oliver and J. M. Cage, Electronic Measurements and Instrumentation, McGraw-Hill, 1971.
3. A. K. Sawhney, Electronic Measurement and Measuring Instruments, Dhanpat Rai & Co., 2005.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	2	1	1	0	0	2	1	0	2
CO2	3	2	2	2	2	1	1	0	2	1	1	2
CO3	3	3	3	2	3	1	2	0	2	2	1	2
CO4	3	3	3	3	3	2	2	1	3	2	2	2
CO5	3	3	3	3	3	2	1	0	2	2	2	2

Year and Semester: First Year, Second Semester
Course Title: Communication Skills (HUL 101)

Course Code:	HUL 101	**Course Title:**	Communication Skills			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			2	0	2	3
Pre-Requisite (if Any)		**Type of Course**	Humanities			

Rationale

The Bachelor's degree holder in Computer Science Engineering or Electronics Communication and Engineering has to work in the industry. To get the expertise and know the technology in his respective field, it is necessary to know effective communication, team building, leadership quality, good interpersonal skills, and the recent trend in Engineering and Technology.

Competency

For engineers to be successful throughout their careers, communication skills are just as important as technical knowledge. Work doesn't happen in a vacuum. Engineers have to communicate daily with each other, with supervisors, with people in different departments, and even with clients. Their work is complex and technical, but not everyone they work with has the same technical expertise, which makes it even more important for them to have good communication skills. Effective communication in engineering is critical to ensuring that all project participants are on the same page. This course enhances the oral and written communication of students.

Course Outcomes:

1. Utilize functional English grammar for accurate and enhanced language skills.
2. Construct and use effective interpersonal and workplace communication
3. Acquire better reading comprehension, pronunciation and reading skills
4. Introspect and illustrate the personality traits and soft skills
5. Develop the skills for better pre and post placement communication through effective presentations, personal interviews and group discussions

Course Contents:

Module I:

Communication: Definition of Communication, Process of Communication, Stages of Communication, Content of the message, Types of communication, Transmission, Medium/Modes of Communication, Verbal and Non-verbal Communication (Kinesics, Proxemics, Chronemics, Haptics, Paralinguistic Feature), Levels of Communication, Flow of Communication, Communication Networks, Grapevine, Barriers to Communication, Choice of Medium,

Module II:

Listening Skills**:** Art of Listening, Listening vs Hearing, (Poor Listening vs Effective Listening), Advantages of Good Listening, Barriers to Effective Listening, Techniques of Effective Listening

Reading Skills: Reading Comprehensions, Process of Reading, Techniques of Reading, Techniques for Good Comprehension, Reading Skills(Skimming, Scanning, Intensive Reading, SQ3R), Orientation in Literary and Scholarly Article

Module III:
Speaking Skills: Types of Speech, Public Speaking, Components of Effective speech, Stage Presence & Personality Development, Clarity and Fluency, Body Language, , Barriers to Effective Speaking
Presentation Skills: Characteristics of a Successful Presentation, Power Point Presentation, Using Audio Visual Aids

Module IV:
Group Discussion: Do's and Don'ts of GD, Essential Skills for GD, Evaluation Pattern
Personal Interview: Objectives of Interview, Types of Interview, Job Interviews, Employer's Expectations, Do's & Don'ts of Social Media Profile, Success Factors, Failure Factors

Module V:
Grammar: Transformation of Sentences, Punctuation, Spellings and Mechanics of Writing

Text Books:

1. Orient Longman, A Textbook of English for Engineers and Technologists.
2. M. Ashraf Rizvi, Effective Technical Communication, Tata McGraw-Hill Publishing Company Limited, 2009.

Reference Books:

1. R. Quirk and S. Greenbaum, A University Grammar of English, Longman.
2. N. Krishnaswamy, English Grammar, Macmillan India Ltd.
3. S. Kumar and P. Lata, Communication Skills, Oxford University Press.
4. M. Raman and S. Sharma, Technical Communication, 2nd ed., Oxford University Press, 2011.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Presenting a Book Chapter using PowerPoint slides
2. Speaking Skills
3. Presentation Skills
4. Group Discussion
5. Personal Interview/ SWOT Analysis
6. Comprehending a Technical Report/News Paper Article

Second Year

Year and Semester: Second Year, Third Semester
Course Title: Applied Signals and Systems (ECL 211)

Course Code:	ECL 211	**Course Title:**	Applied Signals and Systems			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Understand various properties of continuous time signals.
2. Analyse the frequency spectrum of continuous time signals.
3. Describe a LTI system with impulse/frequency response.
4. Analyse magnitude/phase response of various LTI systems.
5. Analyse systems commonly used in communications, control and signal processing.

Course Contents:

Module I:
Introduction to Signals and Systems: The unit impulse and unit step functions, Continuous time signals, Transformation of the independent variables, Exponential and sinusoidal signals, continuous time systems and basic systems properties.

Module II:
Linear time invariant systems: Continuous time linear time invariant (LTI) system, Discrete time LTI system, properties of LTI systems, System representation through linear constant coefficient differential equations.

Module III:
Analysis of continuous time signals and systems: Fourier series representation, convergence of the Fourier series, properties of the Fourier series, Fourier series and LTI systems, Filtering, Example of filters, Representation of aperiodic signals, Fourier transform of periodic signals, Properties of Fourier transform, convolution and multiplication properties and their effects in frequency domain, magnitude and phase response, The Laplace transform of continuous time signals and systems, The notion of Eigenvalue and Eigne function of LTI system, Region of convergence, system function, poles and zeros of systems functions and signals, properties of Laplace transform, Analysis and characterization of LTI system using the Laplace transform, The unilateral Laplace transform, Applications of signals and systems theory.

Module IV:
Analysis of Discrete time signals and systems: Discrete time signals and their Fourier transform (DTFT), Discrete Fourier transform (DFT) and inverse discrete Fourier transform (IDFT), Fast Fourier transform (FFT), Z transform and its region of convergence, properties of Z transform, unilateral Z transform,

relationship between Z transform and DTFT, solution of constant coefficient difference equation using unilateral Z transform.

Module V:

Random variables and response of LTI system for random signals: Introduction to random signals and probability, probability functions, probability distribution function and probability density function, classification of random processes and correlation functions, cross correlation function and their properties, spectral density, response of linear systems to random inputs, frequency domain analysis of LTI system for random signals.

Text Books:

1. A.V. Oppenheim, A. S. Willsky, and S. H. Nawab, Signals and Systems, 2nd Ed., Prentice Hall, 2003.
2. J.G. Proakis and D. G. Manolakis, Digital Signal Processing. Principles, Algorithms, and Applications, 4th Ed., Pearson International, 2014.

Reference Books:

1. S. Haykin and B. V. Veen, Signals and Systems, 2nd Ed., Wiley, 2007.
2. B.P. Lathi, Principles of Linear Systems and Signals, 2nd Ed., Oxford University Press, 2009.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Synthesis of basic elementary signals and verification of their properties.
2. Implementation of linear convolution.
3. Implementation and verification of Discrete time Fourier transform (DTFT) and verification of properties of DTFT.
4. Implementation of Inverse Discrete time Fourier transform (IDTFT)
5. Implementation and verification of Discrete Fourier transform (DFT) and verification of properties of DFT.
6. Implementation of Inverse Discrete Fourier transform (IDFT).
7. Verification of Parseval's theorem.
8. Implementation of Fast Fourier transform (FFT) and verification of its computational efficiency over conventional algorithm.
9. Implementation of Z transform and verification of its properties.
10. De noising of signal in Fourier domain

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	0	0	3	0	0	0	0	0	0	0
CO2	3	3	0	0	1	0	0	0	0	1	0	1
CO3	3	3	3	2	3	0	0	0	0	2	0	1
CO4	3	3	3	3	3	0	0	0	0	2	0	1
CO5	3	3	0	0	0	1	0	0	1	1	0	1

Year and Semester: Second Year, Third Semester
Course Title: Introduction to Object Oriented Programming (CSL 202)

Course Code:	CSL 202	**Course Title:**	Introduction to Object Oriented Programming			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Computer programming	**Type of Course**	Computer Science and Engineering			

Course Outcomes:

1. Evaluate various object oriented paradigms like abstraction, encapsulation, inheritance, polymorphism, information hiding, exception handling.
2. Identify the implementation difference between different object oriented programming languages.
3. Analyse a problem description and design a software flow.
4. Develop object-oriented software using best coding practices.
5. Assess object- oriented solutions for various real word problems.

Course Contents:

Module I:
Object oriented programming, features of object oriented programming languages like data encapsulation, inheritance, polymorphism and late binding.

Module II:
Concept of class, Access control of members of class, instantiating a class, static and non-static members, overloading a method, deriving a class from another class, access control of member under derivation, different ways of class derivation, overriding a method, run time poly morphism.

Module III:
Concept of abstract class, concept of an interface, implementation of an interface, exception-handling mechanism, study of exception handling mechanism in object-oriented languages.

Module IV:
Introduction to streams, use of stream classes, serialization and de-serialization of objects, templates, implementation of data structures like linked lists, stacks, queues, trees, graphs, hash tables using object oriented programming languages.

Module V:
Introduction to concept of refactoring, modelling techniques like UML, Design patterns.

Text Books:

1. B. Stroustrup, The C++ Programming Language, Addison-Wesley.
2. H. Schildt, C++: The Complete Reference, 4th ed.
3. K. Arnold and J. Gosling, The Java Programming Language, Addison-Wesley.
4. M. Weisfeld, The Object-Oriented Thought Process, Pearson.
5. B. Cox, Object-Oriented Programming: An Evolutionary Approach, Addison-Wesley.

Reference Books:

1. B. D. McLaughlin, G. Pollice, and D. West, Head First Object-Oriented Analysis and Design.
2. M. Weisfeld, The Object-Oriented Thought Process.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Simple programs in C++ using inbuilt input/output operators
2. Function overloading and default arguments in C++
3. Namespaces, object creation and dynamic memory allocation in C++
4. Constructor, destructor and copy constructors in C++
5. Operator overloading and friend functions in C++
6. Inheritance in C++
7. Run time polymorphism/ virtual function in C++
8. Function and class template programs in C++
9. Basic JAVA programs demonstrating the input and output and object creation in JAVA
10. Inheritance in JAVA
11. Exception handing in C++/JAVA
12. File handling in C++/JAVA

Year and Semester: Second Year, Third Semester
Course Title: Sensors and Transducers (ECL 212)

<table>
<tr><td>Course Code:</td><td>ECL 212</td><td>Course Title:</td><td colspan="4">Sensors and Transducers</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Nil</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. Interpret different parameters of instrumentation systems
2. Illustrate principle, working and use of sensors.
3. Illustrate principle, working and use of transducers.
4. Demonstrate applications of different transducers.
5. Interpret different parameters of signal conditioning and data acquisition systems

Course Contents:

Module I:
Block schematic of general instrumentation system (Analog and digital),static and dynamic characteristics of instrumentation system, errors in instrumentation system, standard and calibration voltage, current, frequency, impedance

Module II:
Sensor principles, sensor scaling, classification and types of sensor, semiconductor sensors, acoustic sensors, mechanical sensors, magnetic sensors, radiation sensor, ultrasonic sensor, fibre optic sensors, Thermal sensors, chemical sensors, Biosensors, integrated sensors, smart sensors

Module III:
Introduction to transducers, advantages and disadvantages of electrical transducers, transducers actuating mechanism, transducer terminology, design and performance characteristics, criteria for transducer selection, active and passive transducer and their classification. mechanical transducer, passive electrical transducer, resistive, inductive and capacitive transducer, active electrical transducer, thermoelectric, piezoelectric, magnetostrictive, Hall effect, electromechanical, electrochemical, photoelectric and ionization transducer, digital transducer, feedback transducer system.

Module IV:
Applications of transducers, displacement, velocity, acceleration, force, stress, strain, pressure and temperature measurement, flow meters and level sensors, pressure transducers, sound and ultrasonic transducer, phototubes and photodiodes, photovoltaic and photoconductive cells,

photo emission, photo electromagnetic detectors, pressure actuated photoelectric detectors, design and operation of optical detectors, detector characteristics.

Module V:
Signal conditioning systems—amplifiers, filters, A/D converters, DAC's, objective and configuration of data acquisition system, data conversion.

Text Books:

1. D. Patranabis, Sensors and Transducers, 2nd Ed., PHI Learning, 2003.

Reference Books:

1. A. K. Sawhney, A Course in Electronic Measurements and Transducers. Dhanpat Rai & Co., 19th Ed., 2016
2. S. M. Sze, Semiconductor Sensors, illustrated ed., Wiley-Interscience, 1994.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Measurement of temperature and pressure using Arduino
2. Measurement of water flow using Arduino
3. To compute the wind speed using proximity sensors and Arduino
4. To display the distance the object is placed from the sensor using Arduino
5. To study the characteristics of variable capacitor
6. To study the characteristics of light dependent resistor
7. To study the characteristics of Crompton potentiometer
8. To study the characteristics of resistance temperature detector
9. To study the characteristics of thermistor
10. To study the characteristics of thermocouple
11. To study the characteristics of LVDT
12. To study the characteristics of piezoelectric transducer
13. To study the characteristics of Hall effect transducer

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	0	0	0	0	0	0	2	3	2	1
CO2	3	1	0	0	2	0	0	0	2	3	2	3
CO3	3	1	0	0	2	0	0	0	2	3	2	3
CO4	3	2	2	0	2	0	1	0	2	3	2	3
CO5	3	1	0	0	0	0	0	0	2	2	1	2

Year and Semester: Second Year, Third Semester
Course Title: IoT - Workshop-II (ECP 201)

Course Code:	ECP 201	**Course Title:**	IoT Workshop II			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			0	0	4	2
Pre-Requisite (if Any)	IoT workshop I	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Examine the working principle of basic electronic system.
2. To conceptualize simulation of IoT system.
3. Model a physical component for the IoT system.
4. Design an IoT system using components for the IoT.
5. Troubleshoot the connectivity among the components of IoT.

Course Contents:

Module I:
Analysis of the major components of the IoT system

Module II:
Analysis of program for efficiency and low power consumption along with high performance

Module III:
Analysis of IoT data stored on cloud servers

Module IV:
Handling of big data

Module V:
Analysis of different communication network protocols and use of suitable one to establish the system

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	1	0	0	3	3	2	2
CO2	3	2	2	2	2	1	0	0	1	2	2	2
CO3	3	3	3	2	2	2	2	0	2	2	2	2
CO4	3	3	3	2	2	1	1	1	2	2	3	2
CO5	2	2	1	3	1	0	0	0	3	3	2	2

Year and Semester: Second Year, Third Semester
Course Title: Programming techniques for IoT (CSL 217)

<table>
<tr><td>Course Code:</td><td>CSL 217</td><td>Course Title:</td><td colspan="4">Programming techniques for IoT</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>2</td><td>0</td><td>2</td><td>3</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Computer Programming</td><td>Type of Course</td><td colspan="4">Computer Science and Engineering</td></tr>
</table>

Course Outcomes:

1. Write, debug and test program using python
2. Interact with sensors, actuators and shields and work with real time IoT
3. Prototype and develop IoT solutions from scratch with python
4. Develop IoT projects with Arduino and Raspberry PI along with python

Course Contents:

Module I:

Introduction to Python programming: Python foundation, python tools, special output and functions, local and global variables, repetition structures and strings, list, tuple and dictionaries, files and extensions

Module II:

Interfacing micro controller and python: Introduction to controller, python programming with micro controller, weather monitoring UTH -1 temperature sensor, installation of Pyserial, testing sketch for various DTH humidity/ temperature sensor, smart trashcan, water level sensor

Module III:

Programming single board computer (SBC) with python:
Working of GPIOs, Basic python programs such as program for blinking a LED, set the LED's state from user input, add a push button to a circuit, detect when a button is pressed with python, power on the LED when the button is pressed, optimize code with lists and functions

Module IV:

Python 3 and the terminal: Install python modules, work with python from terminal, read, write and manipulate files with python, write python script from terminal, send an email from SBC, add an attachment to the email

Module V:

Add vision to applications and create web applications: Enable the camera, Take a photo from the terminal, record a video from the terminal, Take a photo with python, record a video with python, Write first web server, Add a new URL and connect Flask with GPIOs, choose LED to power on from a web browser.

Text Books:

1. G. C. Hillar, Internet of Things with Python, 1st ed., Packt Publishing, 2016.

Reference Books:

1. B. Klones, Python Codebook: Recipes for Mastering Python 3, 1st ed., 2011.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Familiarization with the concept of IoT, Arduino/ Raspberry pi and perform necessary software installation
2. Study of different operating systems for Raspberry pi/ beagle board. Understanding the process of operating system installation on Raspberry pi/ beagle board
3. Study of connectivity and configuration of Raspberry pi/ beagle board circuit with basic peripherals, LED's, understanding GPIO and its use in program
4. Interfacing of temperature sensor and LED bar
5. Interfacing of IR sensor
6. Interfacing of camera
7. Interfacing of stepper motor
8. Client server configuration and applications for IoT system
9. Use of Raspberry pi for cloud computing
10. Real time intrusion detection for smart home

Year and Semester: Second Year, Third Semester
Course Title: Electromagnetic Field Theory (ECL 213)

Course Code:	ECL 213	**Course Title:**	Electromagnetic Field Theory			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	0	3
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Apply vector calculus for static electric and magnetic fields in different coordinate systems.
2. Calculate electric and magnetic fields due to various charge and current distributions.
3. Solve boundary value problems for electromagnetic fields.
4. Analyze electromagnetic wave propagation in different mediums.
5. Illustrate the antenna theory, terminology and various types of antennas.

Course Contents:

Module I:
Vector calculus:
Cartesian, Cylindrical and spherical co-ordinate systems, differential lengths, surfaces and volumes, Gradient, Divergence, curl operations, Divergence theorem and Stoke's theorem.

Module II:
Electrostatics and Magnetostatics:
Coulomb's law, Electric field intensity, electric flux density, Gauss's law and applications, potential difference and potential gradient, Electric dipole, Energy in the electric field, continuity equation, electric boundary conditions, Biot Savart's law, Amperes circuital law and applications, Magnetic field intensity and flux density, scalar and vector magnetic potentials, magnetic boundary conditions.

Module III:
Maxwell's Equations and Uniform Plane Wave:
Faraday's law, displacement current, Maxwell's Equations in point & integral form, Retarded potentials, wave equation in different mediums, wave impedance, Skin depth, Poynting's theorem.

Module IV:
Wave propagation in Dispersive Media:
Normal incidence, standing waves, laws of reflection, the reflection of obliquely incident waves, Brewster's angle, wave polarization; linear, elliptical and circular polarization.

Module V:
Antenna Basics and Types:
Introduction, Basic Antenna Parameters, radiation Patterns, Beam width, Radiation Intensity, Beam efficiency, Directivity and Gain, Antenna Aperture Effective height, Bandwidth, Radio communication Link, and Antenna Field Zones, losses in antenna, Types of antennas.

Text Books:

1. W. H. Hayt, and J. A. Buck, Engineering Electromagnetics, 8th Ed., Tata McGraw-Hill, 2012.
2. M. N. O. Sadiku, Elements of Electromagnetics, 7th Ed., Oxford University Press, 2018.

Reference Books:

1. G. Raju, Antennas and Wave Propagation, Pearson Education India, 2006.
2. J. D. Kraus, Antennas for All Applications, McGraw-Hill, 2004.
3. R. Shevgaonkar, Electromagnetic Waves, McGraw-Hill Education, 2017.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	1	1	0	0	0	0	0	0	0	0
CO2	3	3	1	1	0	0	0	0	0	0	0	0
CO3	3	3	3	2	0	1	0	0	1	1	0	2
CO4	3	2	3	3	1	2	1	1	1	2	0	2
CO5	3	3	3	2	2	3	2	2	2	2	1	2

Year and Semester: Second Year, Fourth Semester
Course Title: DSP and Applications (ECL 214)

Course Code:	ECL 214	**Course Title:**	DSP and Applications			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Applied Signals and Systems	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Identify different transforms and examine the discrete time signals and systems.
2. Implementation of LTI system as filters for filtering different real world signals.
3. Assess all frequency transforms for stationary and non-stationary signals.
4. Examine different signals and design of algorithms for processing single and multi-dimensional.
5. Filtering of data for IoT applications.

Course Contents:

Module I:

Advantages of digital over analog signal processing, basic elements of DSP and its requirements, Review of Concepts of Signals and Systems. Fourier transform (FFT), decimation in time and decimation in frequency using radix-2 FFT algorithm and radix-4 FFT algorithm, linear filtering using overlap add and overlap save method.

Module II:
FIR filter design, ideal filter requirements, Gibbs phenomenon, windowing techniques, characteristics and comparison of different window functions, design of linear phase FIR filter using windows and frequency sampling method. FIR filters realization, Finite word length effect in FIR filter design.

Module III:
IIR filter design Concept of analog filter design, Designing of analog filters (Butterworth filters and Chebyshev filters), Transform using approximation of derivatives, impulse invariance method, Bilinear transformation method, warping effect. IIR filter realization.

Module IV:
Adaptive filters, WLS technique, Wigner-Ville filter, Empirical Mode Decomposition, singular value decomposition, introduction to wavelets.

Module V:
Introduction to biomedical signal, seismic signal, image as 2- dimensional signal, RADAR signals and analysis of these signals.

Text Books:

1. A.V. Oppenheim, and R.W. Schafer, Discrete Time Signal Processing, 3rd Ed., PHI Ltd, 2014.
2. J.G. Proakis and D. G. Manolakis, Digital Signal Processing. Principles, Algorithms, and Applications, 4th Ed., Pearson International, 2014.

Reference Books:

1. W.D. Stanley, Digital Signal Processing, Reston Publishing Company, Prentice-Hall Company, 1975.
2. S.K. Mitra, Digital Signal Processing A Computer -Based Approach, Tata McGraw-Hill, Edition, New Delhi, 2001.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Synthesis of the basic elementary signals and verification of the signal's properties.
2. Implementation of the linear convolution.
3. Implementation and verification of Discrete Time Fourier Transform (DTFT) and verification of properties of DTFT.
4. Implementation of Inverse Discrete Time Fourier Transform (IDTFT).
5. Implementation and verification of Discrete Fourier Transform (DFT) and verification of properties of DFT.
6. Implementation of Inverse Discrete Fourier Transform (IDFT).
7. Verification of the Parseval's Theorem
8. Implementation of Radix-2 and Radix-4 Fast Fourier Transform (FFT) and verification of its computational efficiency over conventional algorithms.
9. Implementation of z-Transform and verification of its properties.
10. Verification of Poles and Zeros effect on frequency response of linear time invariant system.
11. Design of Finite Impulse Response Filter using Windowing and Frequency Sampling Techniques.
12. Design of IIR filter using Bilinear Transform (BLT) Technique and verification of frequency warping.
13. Design of FIR and IIR Notch filter.
14. Implementation of FIR filter on DSP module.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	0	3	0	0	0	0	0	0	0
CO2	3	3	0	0	1	0	0	0	1	1	0	1
CO3	3	3	3	2	3	1	0	0	0	2	0	1
CO4	3	3	3	3	3	1	0	0	1	2	0	1
CO5	3	3	0	0	0	1	0	0	1	1	0	1

Year and Semester: Second Year, Fourth Semester
Course Title: Modelling for IoT (ECL 215)

Course Code:	ECL 215	**Course Title:**	Modelling for IoT			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. To develop understanding of theory of projection, improve visualization skills and to draw professional technical projections of engineering objects.
2. To develop skills in CAD modeling and analysis Software(s) and to visualize development of surfaces.
3. To understand stresses in geometric primitives and design engineering devices.
4. To conceptualize modeling and simulation of physical systems.
5. To understand failure theories and implement them in CAD modeling.

Course Contents:

Module I:
Projections, isometric projections, development of surfaces. Geometrical Clipping, Transformation. Viewing, filling, Line – Circle algorithms. Modeling of industrial and service devices.

Module II:
Introduction to CAD, applications, Softwares, AUTOCAD, modelling and editing commands. Concept of Layers, annotation. Problems in 2D and 3D. Rendering in AUTOCAD. Concept of Block. Layout building. Solid editing and isometric modelling. Application oriented exercises.

Module III:
Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain, Plane stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes.

Module IV:
Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations. shear forces and bending moments in beams, UDL,VDL. Pure bending, Curvature of a beam, Longitudinal strains in beams.
Torsion in Circular solid and hollow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts. Buckling of columns. Truss and its design.

Module V:
Modeling of devices. Vibration of 1 DOF, 2 DOF systems. Shear force bending moment diagrams, Truss and its synthesis. Design and failure theories. Introduction simulation, queuing, randomness, analysis of simulation data. concept of the finite element method, comparison of FEM with direct analytical solutions; Steps in finite element analysis of physical systems, Finite

Element analysis of 1-D problems like spring, bar, truss and beam elements formulation by direct approach; development of elemental stiffness equations and their assembly, solution and its post processing.

Text Books:

1. Chandrupatla, Tirupathi & Belegundu, Ashok, Introduction to Finite Elements in Engineering. Pearson Education, Upper Saddle River, New Jersey, 2021, ISBN-10: 0-273-76368-7.
2. Beer, F.P. and Johnston Jr., E.R, Mechanics of materials. 2nd Ed., McGraw-Hill, New York, 1992.

Reference Books:

1. James M. Gere, Stephen P. Timoshenko., Mechanics of Materials. 4th Ed., Publisher Stanley Thornes. 1999, ISBN 074873998X, 9780748739981.

2. Pytel, A. and Singer, F. Strength of Materials. 4th Ed., Harper & Row Publishers, New York, 1987.

3. Bhatt N.D. and Panchal V.M., Elementary Engineering Drawing, Charotar Publishing House, 50th Ed. 2011, ISBN 978-93-80358-17-8.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. Mechanics Lab related to stress, friction, beams.
2. AUTOCAD 2D & 3D modelling.
3. CAD software like CREO – modelling and simulation.
4. FEM software like ANSYS – Analysis of designed devices.
5. Modelling and simulation using spreadsheets.
6. 3ds MAx modeling and simulation
7. Autocad rendering
8. Materials, lighting and environment modeling
9. ANSYS modeling 1D
10. ANSYS 2D, 3D simulation

Note: Lab evaluation and TA would be project based on modelling using Software. Aim is to Model real life IOT devices and explore software(s) for this.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	2	2	1	0	0	0	0	0	1
CO2	3	3	3	3	3	2	0	0	0	0	1	2
CO3	3	3	3	2	2	0	0	0	0	0	0	2
CO4	3	3	3	3	3	0	0	0	0	0	1	2
CO5	3	3	3	2	3	0	0	0	0	0	0	2

Year and Semester: Second Year, Fourth Semester.
Course Title: Microprocessors and Microcontrollers (ECL 216)

Course Code:	ECL 216	**Course Title:**	Microprocessors and Microcontrollers			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Digital Circuits and Hardware Design	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Analyse the architecture microprocessor and microcontroller
2. Understand the implementation of programming using concepts of microprocessors and microcontrollers.
3. Analyse the Interfacing of peripherals and programs to solve prototype problems.
4. Design real-life/ engineering, industry, or consumer applications.
5. Distinguish, Manage, and Assemble the concepts of RTOS (Real-Time Operating System)

Course Contents:

Module I:
Introduction to 8086, pin configuration, Microprocessor architecture, assembler directives, Instruction set, Stacks, assembly language programming Interrupts and Interrupts service routines, Byte and String Manipulation.

Module II:
8086 signals, Basic configurations, System bus timing, System Bus Structure, timing diagrams, concept of paging, memory interfacing, minimum mode and maximum mode of 8086, Peripheral device interfacing.

Module III:
Introduction to Microcontrollers, Programming Model and Architecture of the 8051, Program Development Process and Tools, Addressing Modes and Instruction Set.

Module IV:
The 8051 Hardware, System Design and Troubleshooting, Programming in C, Input/Output Ports, Timers, Serial Communications, Interrupts.

Module V:
Interfacing Keyboards, Display Devices: LED, Seven Segment Display and LCD, ADC, DAC, Relays, Stepper, DC Motors, etc., External Memory and Real-Time Clock, I2C and SPI Protocols, design examples, Concepts of RTOS.

Text Books:

1. M A Mazidi, J G Mazidi, R D McKinlay, The 8051 Microcontroller and Embedded Systems Using Assemble and C, Pearson/Prentice Hall, 2nd Ed.
2. KM Bhurchandi, A K Ray, Advanced microprocessors and Peripherals, McGraw Hill Education India, 2012, 3rd ed.

Reference Books:

1. Kamal, Raj. Microcontrollers: Architecture, Programming, Interfacing and System Design. India, Pearson Education, 2009.
2. K V Shibu, Introduction to Embedded Systems, Tata McGraw Hill Education, India, 2009
3. Lyla B Das; Embedded Systems and Integrated Approach, Pearson, India, 2013, 1st Ed.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. (a) Write an assembly language program using microprocessor 8086 to find out sum of given 'n' 8-bit numbers.
   (b) Write an assembly language program using microprocessor 8086 to perform addition of two 32-bit numbers.
   (c) Write an assembly language program using microprocessor 8086 to perform subtraction of two 32-bit numbers.
2. (a) Write an assembly language program using microprocessor 8086 to perform multiplication of two unsigned 16-bit numbers.
   (b) Write an assembly language program using microprocessor 8086 to perform multiplication of two signed 16-bit numbers.
   (c) Write an assembly language program using microprocessor 8086 to perform multiword division of 32-bit number by 16-bit number.
3. (a) Write an assembly language program using microprocessor 8086 to perform the string operation for sorting a string in an ascending order.
   (b) Write an assembly language program using microprocessor 8086 to perform the string operation for sorting a string in descending order.
4. (a) Write an assembly language program using microprocessor 8086 to find out the smallest number from the given array.
   (b) Write an assembly language program using microprocessor 8086 to find out the largest number from the given array.

5.	(a)	Write an assembly language program using microprocessor 8086 to perform shift logical right operation.
	(b)	Write an assembly language program using microprocessor 8086 to perform shift logical left operation.
	(c)	Write an assembly language program using microprocessor 8086 to perform rotate right without carry operation.
	(d)	Write an assembly language program using microprocessor 8086 to perform rotate left without carry operation.
6.	(a)	Write 8051 code to perform addition of two 8-bit numbers.
	(b)	Write 8051 code to perform addition of numbers present in internal memory locations.
	(c)	Write 8051 code to perform addition of numbers present in external memory locations.
	(d)	Write 8051 code to perform addition of first 10 natural numbers.
7.	(a)	Write 8051 code to find largest number from the given array.
	(b)	Write 8051 code to find smallest number from the given array.
8.		Write 8051 code to find number of even and odd numbers from an array.
9.	(a)	Write 8051 code to find factorial of a number.
10.	(a)	Write 8051 code to sort an array in ascending order.
	(b)	Write 8051 code to sort an array in descending order.
11.		Write 8051 code to generate:
	(a)	Square Wave
	(b)	Rectangular Wave
	(c)	Triangular Wave
12.		Design a BCD counter to count from 00H to 99H in a 7-segment display.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	2	0	0	0	0	1	0	2
CO2	3	3	2	2	3	0	0	0	0	0	0	2
CO3	3	2	3	2	3	0	0	1	0	0	1	2
CO4	3	3	2	3	3	0	0	0	0	1	0	2
CO5	3	3	2	2	3	0	0	0	0	0	0	2

Year and Semester: Second Year, Fourth Semester.
Course Title: Communication Systems (ECL 217)

Course Code:	ECL 217	**Course Title:**	Communication Systems			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Understand signal multiplexing, modulation and demodulation; bandwidth requirements for analog communication systems.
2. The students will be able to evaluate the performance of analogue receiver in the presence of noise.
3. The students will have the deep knowledge of components of the digital communication system.
4. The students will be able to critically think and solve problems related to digital transmission and reception in baseband format.
5. Describe and analyze the digital communication system with spread spectrum modulation and its applications in wireless communication.

Course Contents:

Module 1:

Concept of modulation and demodulation: Concept of modulation and demodulation, Continuous wave (CW) modulation: amplitude modulation (AM) - double side band (DSB); single sideband (SSB) and vestigial sideband (VSB) modulation.

Module II :
AM receivers, angle modulation: AM receivers, angle modulation - frequency modulation (FM); narrow and wideband FM, phase modulation (PM); Representation of narrowband noise; receiver model, signal to noise ratio (SNR), noise figure, noise temperature, noise in DSB-SC, SSB, AM; FM receivers, pre-emphasis and de-emphasis.

Module III :

Pulse code modulation method: Sampling process, sampling theorem for band limited signals; pulse amplitude modulation (PAM); pulse width modulation (PWM); pulse position modulation (PPM) ; pulse code modulation (PCM); line coding; differential pulse code modulation; delta modulation and Adaptive delta modulation.

Module IV :
Basic digital modulations schemes: Basic digital modulation schemes: Amplitude shift keying (ASK), frequency shift keying (FSK), Phase shift keying (PSK) and Quadrature Phase shift keying (QPSK) and QAM Methods. Constellation diagram and its practical applications.

Module V :
Spread spectrum methods: Properties of PN sequences, DSSS system, slow and fast FHSS. Block diagrams and performance analysis, carrier and symbol synchronization. Error control coding: Shannon's channel capacity theorem.

Text Books:

1. S. Haykin and M. Moher, Introduction to Analog & Digital Communication Systems, 2nd Ed, John Wiley, 2007.
2. B. P. Lathi, Modern Analog & Digital Communication Systems, 3rd Ed., Oxford University Press, 1998.

Reference Books:

1. G. Kennedy, Davis B. and Prasanna S.R.M, Electronic Communication Systems, TMH, 6th Ed. 2018.
2. L. E. Frenzel, Communication Electronics: Principles and Applications, 3rd Ed., TMH.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. To Perform Amplitude Modulation And Demodulation
2. To Perform DSB-SC AM Transmitter And Receiver
3. To Perform FM Transmitter And Receiver
4. To Perform Analog Sampling And Reconstruction
5. To Perform PAM Modulation/Demodulation
6. To Perform PWM Modulation/Demodulation
7. To Perform PPM Modulation/Demodulation.
8. Study of TDM-Pulse Code Modulation and Demodulation.
9. Study of ASK, FSK, PSK.
10. Study of QPSK Signalling method.
11. Study of Quadrature Amplitude Multiplexing.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	2	0	0	0	0	1	0	2
CO2	3	3	2	3	2	0	0	0	0	1	0	3
CO3	3	2	2	1	2	0	0	0	0	1	0	2
CO4	3	3	3	2	2	0	0	0	0	1	0	2
CO5	3	2	3	2	3	1	0	0	0	1	1	3

Year and Semester: Second Year, Fourth Semester.
Course Title: Database Management System (CSL 301)

Course Code:	CSL 301	**Course Title:**	Database Management System			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Computer Science Engineering			

Course Outcomes:

1. Student will be able to design and develop database using ER model with various SQL constraints and apply normalization for consistency in database.
2. Student will be able to write queries using relational algebra, tuple and domain relational calculus, and SQL to retrieve information from database based on data centric applications.
3. Student will be able to analyze and apply the concept of storage management and query processing to fine tune the performance of database at the time of infor-mation retrieval.
4. Student will be able to analyze and apply the conception of transaction processing, concurrency control and recovery mechanism in database.

Course Contents:

Module 1:
Database system concepts and Architecture -concept of relational database, Relational data model,Relational algebra, SQL-the relational database standard, ER and EER model.

Module II:
Database design theory -Functional dependencies and normalization, relational database design algorithms, practical database design and demoralization, Relational constants, programmatic ways for implementing constraints, triggers, Chase algorithm.

Module III:
Physical database design -Concept of physical and logical hierarchy, storage structures like cluster, index organized table, partitions, various table storage parameters and block storage parameters, concept of index, B-trees, hash index, function index, bitmap index.

Module IV:
Process and memory management in database -Various types of tasks in database, database buffer management, log buffer management code reuse, concept of two tier and N-tier architecture, data dictionary and catalog information database recovery technique. Arier Algorithm for recovery.

Module V:
Query optimization and performance tuning -Various techniques for query optimization, strong and weak equivalence, cost base optimization, Use of different storage structures in query optimization.

Module VI:
Transaction Processing -Transaction and system concepts, Desirable properties of transaction, Schedules and recoverability, serializability of schedules, concurrency control, lock base protocols and time stamp based protocols, read consistency.

Text Books:

1. R. Elmasri and S. B. Navathe, Fundamentals of Database Systems, Addison-Wesley, 2000.
2. J. D. Ullman, Principles of Database Systems, Golgotia Publications, 1988.

Year and Semester: Second Year, Fourth Semester.
Course Title: Workshop-III (ECP 202)

Course Code:	ECP 202	**Course Title:**	IoT-Workshop III			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			0	0	4	2
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes: Upon the completion of this course, students will demonstrate the ability to:

1. Evaluate the working principle of electronic systems.
2. Build systems using components of IoT.
3. Demonstrate an update in the existing IoT based system.
4. Design a Single board computer based system using components for the IoT
5. Implement a ML/DL based system using Raspberry Pi.

Course Contents:

Analysis of major components of IoT system

1. Single board computer-based automation system.
2. Single board computer-based image processing system.
3. Biometric system using Single board computer.
4. Case study - 1 using single board computer.
5. Case study - 2 using single board computer.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	2	0	0	0	0	1	0	2
CO2	3	3	2	2	3	0	0	0	0	0	0	2
CO3	3	2	3	2	3	0	0	1	0	0	1	2
CO4	3	3	2	3	3	0	0	0	0	1	0	2
CO5	3	3	2	2	3	0	0	0	0	0	0	2

Third Year

Year and Semester: Third Year, Fifth Semester.
Course Title: Communication Network (ECL 315)

Course Code	ECL 315	**Course Title:**	Communication Network			
Category	Departmental Core (DC)	**Credit Assigned**	**L**	**T**	**P**	**C**
			3	0	2	4
Pre-Requisite (if any)	Nil	**Type of Course:**	Electronics and Communication Engineering			

Course Outcomes:

1. Describe the basics of Computer Network, Data Communication, Network topologies, transmission media and switching techniques.
2. Analyze the services and features of various protocols of Data Link Layer and MAC sub-layer.
3. Apply the concept of IP Addressing techniques and its various protocols of Network Layer.
4. Describe the transport layer, Application Layer services and its protocol Headers and analyze the congestion control protocols.
5. Explain the function of Application Layer and Presentation layer paradigm and protocols.

Course Contents:

Module I:
Overview of Data Communication, Types of Communication: Simplex, Half Duplex, Full Duplex, Introduction to Network, Network Topology, Network classification:- LAN,MAN,WAN,BAN, Network Architecture, Protocols, Services and primitives, OSI Reference Model, TCP/IP Reference Model. Transmission Media: Guided Media, Unguided, Structure of Switch, types of switches, Switching Techniques: Circuit-switching, Message switching, Packet switching, MQTT.

Module II:
Design Issues, Framing methods, Flow Control and Error Control, Stop-and-wait flow control, Sliding-window flow control, Stop-and-wait ARQ, Go-back-N ARQ, Selective repeat ARQ, HDLC, MAC sub layer: ALOHA,CSMA-CD.

Module III:
IOT related services, IoT networks, LORA, Mesh, BLE, Bluetooth networking, Bluetooth mesh network, NIRF-2401, Radio network, radio mesh network.

Module IV:
Network layer duties, Routers, IP addressing and its classification, IPv4 address, IPv6 address, Mask and Subnet, Routing algorithms like Shortest path routing, Djkstra's algorithm, Bellman Ford Algorithm, Distance Vector Routing, Dynamic Routing.

Transport layer services, Connection oriented & Connectionless, Three-way handshaking, UDP model, TCP: TCP header format, comparison between UDP and TCP, Need of Congestion control, Principal of congestion, Quality of Service (QoS), Token bucket and leaky bucket algorithm.

Module V:

Application Layer: DNS, Electronic Mail, File Transfer (FTP), WWW, HTTP. Introduction to Cryptography, Secret key algorithm, public key algorithm, Digital Signature, Basics of Attacks and security. Introduction to HTTP

Text Books:

1. Data Communications and Networking, 4th Ed. by Behrouza A. Forouzan, McGraw-Hill, 2007.
2. Computer Networks, A. S. Tanenbaum, 4th Ed., Pearson education, 2003.

Reference Books:

1. William Stallings, Data and Computer Communications, 10th Ed., Pearson Educations.
2. William Stallings , Cryptography and Network Security Principles and Practice, 8th Ed., , 2023.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based

1. To Study about different physical equipment used for networking.
2. Study of Network Devices in Detail.
3. Connect the computers in Local Area Network.
4. Study of basic network command and Network configuration commands.
5. Program to generate CRC code for checking error.
6. To Plot Efficiency of pure Aloha and slotted ALOHA in MATLAB.
7. To Plot Channel Efficiency for Ethernet in MATLAB.
8. To Study RSA – Public Key Cryptography Algorithm.
9. To Study the Network Simulator (NS2).
10. To Implement wired network topology and wireless network topology in ns2.
11. To Implement UDP protocol and study performance using network simulator (ns2).

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	2	0	0	0	0	1	0	0
CO2	3	3	1	2	3	0	0	1	0	0	0	0
CO3	3	2	3	2	3	0	0	1	0	1	1	1
CO4	3	3	1	3	0	0	0	0	0	1	0	1
CO5	3	3	2	2	3	0	0	0	0	0	0	2

Year and Semester: Third Year, Fifth Semester.
Course Title: Embedded Systems (ECL 308)

<table>
<tr><td>Course Code:</td><td>ECL 308</td><td>Course Title:</td><td colspan="4">Embedded Systems</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Core (DC)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Micro Processor and Micro-controller</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. Apply development flow for designing an embedded system.
2. Demonstrate the ability to select and program suitable microcontroller for embedded system.
3. Identify suitable peripheral devices as per requirement of embedded system.
4. Rectify faults and revamp embedded system's design as per the requirement.
5. Manage resources for different tasks in embedded system.

Course Contents:

Module I:

Embedded Systems: Introduction, Overview and Characteristics. Concept of Real time Systems, Challenges in Embedded System Design.

Module II:

Design Process: Requirements, Specifications, Architecture Design, Designing of Components, System Integration.

Module III:

Embedded System Architecture: (a). Instruction Set Architecture: CISC and RISC instruction set architecture Design Process (b). Basic Embedded Processor/Microcontroller Architecture: CISC Examples, RISC Example, DSP Processors, Harvard Architecture (PIC).

Module IV:

Interfacing: (a). Memory Interfacing (b).I/O Device Interfacing: Interfacing Protocols, I/O Devices

Module V:

OS for Embedded Systems: Basic Features, Kernel Features, Processes and Threads, Context Switching, Scheduling, Inter-process Communication, Real-time Memory Management, I/O and Example Real-time OS

Design Examples: (any two) Washing Machine, Air Conditioner, PID system for boiler etc.

Text Books:

1. K. J. Ayala, The 8051 Microcontroller: Architecture, Programming, and Applications, 2nd Ed., Delmar Cengage Learning, 1996.

2. M. A. Mazidi, The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 1st Ed., Pearson Education India, 2007.

Reference Books:

1. J. W. Valvano, Embedded Microcomputer Systems: Real-Time Interfacing, 3rd Ed., Cengage Learning, 2012.
2. J. Ganssle, The Art of Designing Embedded Systems, 2nd Ed., Newnes, 2008.
3. D. E. Simon, An Embedded Software Primer, 1st Ed., Addison-Wesley Professional, 1999.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any):

Sr. No.	Theme	Experiments
1.	Design Process	Understand the design process and estimate system's requirement, Specifications, Architectural Design, and Components for System Integration.
2.	Interfacing	Interfacing of peripheral devices like; Led, 7-segment,
3.	Interfacing	Design a digital watch and interface a LCD Display,
4.	Interfacing	Stepper and servo motors with the microcontroller.
5.	Timers	Design timers and simulate different timing operations and waveforms of different duty cycles.
6.	Interfacing	Understand Serial communication interfacing of devices with microcontroller.

7.	Interrupts	Understand interrupts and use those to control devices using microcontroller.
8.	OS for Embedded Systems	Study effect of context switching and scheduling on performance of embedded system.
9.	Design Examples	Develop a system to control temperature inside the boiler as per the setting provided.
10.	Design Examples	Develop an embedded system for the Washing Machine.
11.	Design Examples	Develop an embedded system for an Air Conditioner.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	1	0	0	0	0	0	0	2
CO2	3	3	2	1	1	0	0	0	0	0	2	2
CO3	3	3	3	3	1	1	0	0	1	1	2	2
CO4	3	3	3	3	2	1	0	0	2	2	2	2
CO5	3	3	3	3	1	1	0	0	2	2	3	2

Year and Semester: Third Year, Fifth Semester.
Course Title: IoT Security (ECL 316)

Course Code:	ECL 316	**Course Title:**	IoT Security			
Category:	Departmental Core (DC)	**Credit Assigned**	L	T	P	C
			3	0	0	3
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

On successful completion of the course, students will be able to:

1. Understand IoT Architecture and Components
2. Identify IoT Security Threats
3. Evaluate IoT Protocols for Security
4. Apply Device and Data Security Measures
5. Assess Real-World IoT Security Breaches

Course Contents:

Module I:

Introduction to IoT and Security Fundamentals: Overview of IoT Systems: Definition and architecture of IoT, IoT communication models: Device-to-Device, Device-to-Cloud, Device-to-Gateway, Applications of IoT in smart cities, healthcare, industrial IoT, etc. IoT Ecosystem and Security Challenges: Characteristics of IoT devices and networks, Overview of IoT security risks, Key differences between IoT security and traditional network security

Basic Concepts of Security: Confidentiality, Integrity, and Availability (CIA triad), Authentication, Authorization, and Encryption, Attacks: Malware, Man-in-the-Middle, Denial of Service (DoS), etc.

Module II:

IoT Network Protocols and Their Vulnerabilities: IoT Communication Protocols: MQTT, CoAP, AMQP, Zigbee, Bluetooth Low Energy (BLE), and 6LoWPAN, Security features and vulnerabilities in IoT protocols. Wireless Security in IoT: Security in Wi-Fi, Bluetooth, Zigbee, Challenges in securing low-power wireless networks

Common Threats to IoT Networks: Replay attacks, Eavesdropping, Sybil attacks, Sinkhole attacks

Module III:

Security for IoT Devices and Data: Device Security: Secure boot, Secure firmware updates, Hardware security and Trusted Platform Module (TPM), Secure coding practices for IoT devices. Data Security and Privacy in IoT: Data lifecycle and its security, Securing data at rest, in transit, and in use, Data privacy issues and compliance (GDPR, HIPAA for IoT)

End-to-End Security in IoT Systems: Threat modeling for IoT systems, Securing IoT applications and endpoints

Module IV:

IoT Security Frameworks, Standards, and Best Practices: IoT Security Standards and Frameworks: Overview of IoT security standards: ISO/IEC 27001, NIST IoT cybersecurity framework, IoT security lifecycle management: Planning, Risk assessment, and Monitoring Best Practices in IoT Security: Secure network design and segmentation, Identity and Access Management (IAM) for IoT, Intrusion Detection and Prevention Systems (IDS/IPS) for IoT Regulations and Compliance: Legal and regulatory issues in IoT security, Role of governments and industry bodies

Module V:

Emerging Threats and Future of IoT Security: Emerging IoT Threats, Botnets and DDoS attacks (e.g., Mirai), Ransomware in IoT, Zero-day attacks and Advanced Persistent Threats (APTs). Future Trends in IoT Security: Machine learning and AI for IoT security, Blockchain technology in IoT for security and privacy, Quantum computing and its impact on cryptography for IoT.

Text Books:

1. D. Van Duren and B. Russell, Practical Internet of Things Security, 1st Ed., Packt Publishing, 2016.

Reference Books:

1. F. Hu, Internet of Things (IoT) Security: Fundamentals, Techniques and Applications, CRC Press, 2016.

2. David Etter, IoT Security: Practical Guide Book, 1st Ed., Create Space, 2016.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	0	0	2	0	0	1	0	0	0	1
CO2	3	2	0	0	2	0	0	2	0	0	0	1
CO3	3	3	2	2	3	0	0	2	0	0	0	2
CO4	3	3	2	2	3	0	0	2	0	0	0	2
CO5	3	3	2	3	3	0	0	2	0	0	0	2

B.Tech
ECE(IoT) Syllabus
Elective Courses
IIIT Nagpur

List of Elective Courses

Course Code	Course Title	L	T	P	Credits
ECL 422	Process control systems	3	0	2	4
ECL 423	Cloud Computing	3	0	2	4
ECL 424	Data Analytics	3	0	2	4
ECL 425	AI-ML in IoT	3	0	2	4
ECL 426	Industrial IoT	3	0	0	3
ECL 437	Statistical Signal Analysis	3	0	2	4
ECL 441	Computer Vision	3	0	2	4
BEL 403	Robotics	3	0	2	4
ECL 458	Real Time Operating Systems	3	0	2	4
ECL 462	Fundamentals of Machine Learning	3	0	2	4

Course Title: Process Control System (ECL 422)

Course Code:	ECL 422	**Course Title:**	Process Control Systems			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Analyze the process control system and evaluation.
2. Applications of electronic and pneumatic controller in control systems.
3. Illustrate PID controller for improving the transient response.
4. To discuss final control elements
5. Compare and analysis of conventional and smart tuning techniques.

Course Contents:

Module 1:
Introduction to process control Control system Evaluation. ON-OFF control, Time proportional control, proportional control, Integral control, Derivative control. Typical Time-Domain Analysis of Feedback Control Systems - Typical reference test signals and their significance, transient behaviour of closed loop systems under feedback control.

Module II:
Pneumatic controller: P, PD, PI, PID controllers. Hydraulic controller: P, PI, PD, PID controller, Electronic controller. Complex control schemes: ratio control systems, split range controls, cascade controls, feed forward control.

Module III:
Proportional plus derivative and rate feedback control actions for improving the transient response. Steady state behaviour of closed loop feedback control systems. Types of open loop transfer functions. Steady state errors. Proportional plus integral control action for the improvement of steady state errors.

Module IV:
Final control elements: Mechanical, Electrical, Fluid valves: control valve principles, valve-sport and plug and characteristics, control valve types, Valve sizing and selection. Type of actuators: Pneumatic actuators, Hydraulic actuators.

Module V:

Tuning of controllers: Ziegler-Nicolas methods and other classical methods. Optimization techniques for tuning parameters, GA, PSO, etc.

Text Books:

1. D.Patranabis- Principles of Process Control. Tata McGraw Hill. 3rd Ed, 2012.
2. Donald R Coughanower, Steven E LeBlanc, Process System Analysis & Control, McGraw Hill Education, 3rd Ed., 2017.

Reference Books:

1. S. K. Singh - Industrial Instrumentation. Tata McGraw-Hill 2nd Ed. 2003.
2. M. Mitra & S.S. Gupta- Programmable Logic Controller and Industrial Automation Penram International (India) Pvt Ltd; 2005.
3. B. Wayne Bequette, Process control, modeling, Design and simulation, Prentice Hall of India (P) Ltd., 2003.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Temperature Control using P, PI, PD and PID controllers- Study of output response
2. Flow Control using P, PI, PD and PID controllers- Study of output response
3. Liquid Level Control using P, PI, PD and PID controllers- Study of output response
4. Pressure Control using P, PI, PD and PID controllers- Study of output response
5. Controller Tuning for various processes-using Ziegler Nichols rule
6. Controller Tuning for various processes-using Cohen and Coon rule
7. Controller Tuning - Simulation
8. Block diagram simulation of a complex control system
9. Study of Feed-forward control, cascade and ratio controls
10. Simulation of Genetic Algorithm- use any software
11. Simulation of Heat Exchanger Temperature Control.
12. PID Controller tuning using Metahuristic Algorithm.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	0	0	0	0	0	1
CO2	3	2	2	2	2	0	0	0	0	0	0	1
CO3	3	3	3	2	2	1	1	0	3	0	0	1
CO4	3	2	2	2	2	1	1	0	3	0	0	1
CO5	2	3	3	2	3	2	2	0	3	0	0	1

Course Title: Cloud Computing (ECL 423)

Course Code:	ECL 423	**Course Title:**	Cloud Computing			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Analyze the evolution, architecture, and characteristics of cloud computing systems.
2. Demonstrate knowledge of cloud service and deployment models effectively.
3. Evaluate virtualization techniques and cloud storage mechanisms for resource management.
4. Develop applications using cloud programming environments and IoT integrations.
5. Assess security, privacy, and compliance issues in cloud-based IoT platforms.

Course Contents:

Module I:
Introduction to Cloud Computing, History of Centralized and Distributed Computing –overview of Distributed Computing, Cluster computing, Utility Computing, Grid Computing, etc. Cloud Computing overview, applications, Intranet and the Cloud, First movers in the Cloud. Cloud Computing – benefits, characteristics, challenges, security concerns, regulatory issues. IoT Architecture: Layers of IoT architecture including perception, network, and application layers.

Module II :
Cloud Computing Models And Virtualization: Cloud computing architecture: basic, Components – front-end platform, back-end platform, networking, cloud-based delivery. Cloud Infrastructure Management: Features, Cloud computing stack. Cloud Service Models:- Infrastructure as a Service (IaaS),Platform as a Service (PaaS), Software as a Service (SaaS). Cloud Deployment Models :-Public, Private, Community, Hybrid. Virtualization Concept, HYPERVISOR, Types of Hardware Virtualization:-Full Virtualization, Emulation Virtualization, Para virtualization Cloud Storage Architecture, Types of Cloud Storage, Cloud Storage Providers.Storage Devices :-Block Storage Devices, File Storage Devices, Cloud Storage Classes:-Unmanaged Cloud Storage, Managed Cloud Storage, Creating Cloud ,Storage System, Virtual Storage Containers.

Module III :
Cloud Service Delivery Models: Service Provider and users, Challenges and risks in cloud adoption. Service Level Agreement (SLA) management: Types of SLA, Life cycle of SLA. Service catalog, management and functional interfaces of services, Cloud portal and its functions, Cloud Service life cycle phases: Service planning, service creation, service operation and service termination

Module IV :

Cloud Programming And Software Environments: Cloud Programming and Software Environments – Parallel and Distributed Programming paradigms – Programming on Amazon AWS and Microsoft Azure – Programming support of Google App Engine – Emerging Cloud software Environment. IoT Applications Smart Homes: (Home automation, security systems, and energy management) Smart Cities: (Urban planning, traffic management, and public safety) Healthcare IoT: (Wearable devices, remote monitoring, and telemedicine) Agricultural IoT: (Precision farming, soil monitoring, and smart irrigation).

Module V :

Cloud Security

Infrastructure Security, Network-level security , Host level security , Data Security and Storage, Cloud Access: authentication, authorisation and accounting, Cloud based IoT platform and services, Cloud based IoT data analytics, Cloud based IoT security and privacy, cloud based IoT applications and use cases.

Text Books:

1. Mastering Cloud Computing: Foundations and Applications Programming, Rajkumar Buyya, Christian Vecchiola, Thamarai Selvi, 1st Ed., McGraw Hill Education, 2013, ISBN: 978-0071639840.

2. Cloud Computing: Concepts, Technology & Architecture, Thomas Erl, 1st Ed., Pearson Education, 2013, ISBN: 978-0133387520.

Reference Books:

1. Cloud Computing: A Practical Approach, Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, 1st Ed., McGraw Hill Education, 2010, ISBN: 978-0071626949.

2. Virtualization: A Manager's Guide, Toby Velte, Anthony Velte, 1st Ed., McGraw Hill Education, 2011, ISBN: 978-0071629094.

3. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, Subra Kumaraswamy, Shahed Latif, 1st Ed., O'Reilly Media, 2009, ISBN: 978-0596802769.

4. Cloud Computing: Implementation, Management, and Security, John W. Rittinghouse, James F. Ransome, 2nd Ed., CRC Press, 2017, ISBN: 978-1138035299.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Use Google doc to make spreadsheet and notes

2. Configure/Install a free cloud server using Own cloud or any open source software

3. Create/Delete virtual machines using VMware

4. Implement storage service on cloud using Own Cloud (Open source Software)

5. Hosting a website using Google cloud/Any cloud platform.

6. Hosting a web app using Google cloud/Any cloud platform

7. Configure Web Server on Azure Cloud & secure it .

8. Install Google App Engine. Create hello world app and other simple web applications using python/java

9. Set up a basic IoT device and connect it to a cloud service (temperature and humidity sensor, Arduino IDE).

10. Implement remote monitoring and control of an IoT device through a cloud platform (relay module, LED, temperature sensor).

11. Project (As a part of TA)

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	1	0	0	0	0	0	0	2
CO2	3	3	2	2	2	0	0	0	0	0	1	2
CO3	3	2	2	3	3	0	0	0	0	0	2	2
CO4	2	2	3	2	3	0	0	0	2	2	2	3
CO5	2	3	2	2	2	3	2	3	0	0	2	2

Course Title: Data Analytics (ECL 424)

Course Code:	ECL 424	**Course Title:**	Data Analytics			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Database Management System	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. Explain fundamental concepts and processes involved in data analytics.
2. Apply statistical analysis and hypothesis testing for data interpretation.
3. Implement data mining techniques including clustering and classification methods.
4. Design effective data visualizations using modern visualization tools.
5. Evaluate ethical issues, data privacy, and emerging analytics trends.

Course Contents:

Module I :

Introduction to Data Analytics, Definition and example of data analytics, Responsibilities of a Data Analyst, Qualities and Skills to be a Data Analyst, Applications of Data Analytics, Data Analytics vs. Data Analysis

Data Analysis Process: Data Requirement Specifications, Data Collection, Data Processing, Data Analysis, Infer and Interpret Results. Data Analysis Methods: Qualitative Analysis, Quantitative Analysis, Text analysis, Statistical analysis, Diagnostic analysis, Predictive analysis.

Data cleaning: Importance of data cleaning with real world examples, Methods of data cleaning

Module II :

Data Analysis Techniques and Tools, Statistical hypothesis generation and testing, Chi-Square test, t-Test, Analysis of variance Correlation analysis, Maximum likelihood test, Regression analysis, Classification techniques, Clustering Association rules analysis Introduction to Data Analysis Tools: Excel, Tableau, Power BI, Fine Report,R & Python, SAS

Module III :

Data Mining , Clustering And Applications And Trends In Data Mining, Introduction -Data , Types of Data ,Data Mining Functionalities , Interestingness of Patterns , Classification of Data Mining Systems ,Data Mining Task Primitives ,Integration of a Data Mining System with a Data Warehouse, Issues ,Data Preprocessing, Cluster Analysis - Types of Data – Categorization of Major Clustering Methods ,Kmeans , Partitioning Methods ,Hierarchical Methods ,Density-Based Methods ,Grid Based Methods , Model-Based Clustering Methods ,Clustering High Dimensional Data ,Constraint ,Based Cluster Analysis – Outlier Analysis ,Data Mining Applications.

Module IV :

Introduction to Data Visualization and Data Representation, Basics of data visualization, Principles of good visualization design, Ideas and tools for data visualization, Data visualization

design workflow. Introduction to visual encoding, Chart types, Chart families, Categorical, Hierarchical, Relational, Temporal and Spatial

Module V :
Ethics and recent trends, Data Science Ethics – Doing good data science, Owners of the data Valuing different aspects of privacy. The Five Cs :-Consent, Clarity, Consistency and Trust, Control and transparency, Consequences, Implementation of 5C's , Diversity ,Inclusion, Future Trends. Data masking: Importance, Data masking techniques, Types of data masking, Data masking challenges.

Text Books:

1. Anil Maheshwari, Data Analytics Made Accessible, 3rd Ed., Amazon Digital Services, 2018.

2. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, Pearson Education, 2nd Ed., 2019.

Reference Books:

1. Wes McKinney, Python for Data Analysis, 3rd Ed., O'Reilly Media, 2022.

2. Foster Provost and Tom Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, 2013.

3. Vasant Dhar and Roger Stein, Doing Good Data Science: Doing Data Science Right, MIT Press, 2023.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any) :

1. Apply pivot table of Excel to perform data analysis.
2. Perform data import/export(CSV,XLS,TXT) operations using data frames by R/Python.
3. Perform numerical operations(MAX, MIN, AVG,SUM,SQRT,ROUND) using R/Python
4. Install Tableau, Understand User Interface, Dimensions, Measures, Pages, Filters, Marks and Show Me, Dataset Connections and Create a visualization
5. Perform statistical operations(Mean, Median, Mode and standard deviation)
6. Implement basic data frame analysis using Python
7. Install data mining tool WEKA. Study the GUI explorer on WEKA.
8. Implement data cleaning technique-I (data preprocessing –Finding and replacing Missing value in sample dataset)
9. Implement data cleaning technique-II(Data Transformation-Transforming data from one format to another format on sample dataset)
10. Perform the Histogram Analysis of given dataset using Data Analysis Toolbox of Excel
11. Perform Simple Linear Regression using Data Analysis Toolbox of Excel or with Python and Interpret the regression table

12. Develop a procedure for Visualization of Banking Table
13. Perform Data Representation :- chart types: categorical, hierarchical, relational, temporal & spatial
14. Perform 2-D: bar charts, Clustered bar charts, dot plots, connected dot plots, pictograms, proportional shape charts, bubble charts, radar charts, polar

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	0	0	1	0	2	3	2	1
CO2	3	3	2	3	2	0	1	0	2	3	2	2
CO3	3	3	3	3	2	0	1	0	2	3	2	3
CO4	3	2	2	2	3	0	1	0	2	3	3	2
CO5	2	1	1	2	2	3	3	3	3	3	2	3

Course Title: AI ML in IoT (ECL 425)

Course Code:	ECL 425	**Course Title:**	AI ML in IoT			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. To learn the concepts of searching for AI problems
2. To learn about agents and knowledge representation
3. To understand the various factors involved in inferences
4. To get introduced to fundamentals of machine learning
5. To learn about the possibilities of Supervised and Unsupervised learning

Course Contents:

Module I:

History of AI - Agents - Structure of Intelligent agents - Environments - Problem solving methods - Problem solving agents - Formulating problems - search strategies - Breadth-first - Uniform cost - Depth-first - Depth limited - Bidirectional - Informed Search - Best-first Heuristic Functions - Memory bounded search - Hill Climbing - Simulated annealing - Measure of performance and analysis of search algorithms.

Module II :

Perfect Decisions - Imperfect Decisions - Alpha-beta pruning - Knowledge based agent - Wumpus World Environment - Propositional logic - agent for wumpus world - First order logic - syntax - semantics - extensions - Using First order logic - Representation change in the world - Goal based agents.

Module III :

Knowledge representation - Production based system - Frame based system - Inference - Backward chaining - Forward chaining.

Module IV :

Support vector machine classifier, kernel methods. Decision Trees: Representing concepts as decision trees. Recursive induction of decision trees. Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Occam's razor. Overfitting. Ensemble classifiers: stacking, bagging, boosting. Random forest, Ada Boost algorithm. Performance measures of classification: Confusion matrix, Area under RoC curve. Hypothesis space, Bias and variance, Bias-variance tradeoff, K-fold cross validation.

Module V :

Unsupervised learning: Gaussian mixture model and Expectation maximization (EM) algorithm. K means clustering, Agglomerative clustering, Mean shift clustering, Fuzzy K means clustering. Semi supervised learning with EM.

Text Books:

1. Stuart Russel, Peter Norvig, AI – A Modern Approach, 2nd Ed., Pearson Education, 2007.
2. T. M. Mitchell, Machine Learning. New York, NY, USA: McGraw-Hill, 1997.

Reference Books:

1. Vinod Chandra SS, Anand Hareendran S, "Artificial and Machine Learning", 1st Ed., PHI Learning, 2014.
2. G. Luger, W. A. Sttubblefield, Artificial Intelligence, 3rd Ed., Addison-Wesley Longman, 1998.
3. N. J. Nilson, Principles of Artificial Intelligence, Narosa Publishing House, 1980.
4. Christopher Bishop. Pattern Recognition and Machine Learning. 2nd Ed., 2006.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any) :

1. Heuristics and search strategy for Travelling salesperson problem.
2. Implement n-queens problem using Hill-climbing, simulated annealing, etc.
3. Tic-tac-toe game simulation using search and heuristics.
4. Solve 3-SAT, 3-CNF algorithms using agents.
5. Describe the Sudoku game and represent the actions using First-order / Propositional logic
6. Sorting algorithms employing forward chaining.
7. Logical reasoning examples for E-commerce stores using forward/backward chaining.
8. Study of Machine learning tool.
9. Exercises on decision trees, SVM using the tool.
10 K-means clustering implementation using tool.
11 Agglomerative, divisive, fuzzy clustering using tool

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	2	2	1	1	0	1	2	0	2
CO2	3	3	2	2	3	2	2	1	1	2	2	2
CO3	3	3	2	2	3	2	2	1	1	2	2	2
CO4	3	3	3	3	3	2	2	1	2	2	2	2
CO5	3	3	3	3	3	3	2	2	3	2	3	2

Course Title: Industrial IoT (ECL 426)

Course Code:	ECL 426	**Course Title:**	Industrial IoT			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	0	3
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes: On successful completion of the course, students shall be able to:

1. Understand the basics of Industrial IOT and Medical IoT
2. Identify the technical and industrial requirement procedures for IIoT applications
3. Develop various applications using IIOT architectures
4. Choose selected IOT devices for understanding the system architecture of medical IoT
5. Analyze privacy and security measures for industry and medical standard solutions

Course Contents:

Module I:
Introduction to Industrial IoT: Technical requirements, IoT background-History and definition, IoT enabling factors, IoT applications, IoT key technologies, I-IoT, IoT and I-IoT – similarities and differences, Industry environments and scenarios covered by I-IoT.

Module II:
Understanding the Industrial Process and Devices Technical requirements: The industrial process-Automation in the industrial process, Control and measurement systems, Types of industrial processes.

Module III:
Industrial Data Flow and Devices: Technical requirements, The I-IoT data flow in the factory, Measurements and the actuator chain .Sensors , The converters - Digital to analogical, Analog to digital, Actuators, Controllers - Microcontrollers, Embedded microcontrollers, Microcontrollers with external memory, DSP's. Industrial protocols - Automation networks, The Fieldbus, Developing Industrial IoT and Architecture Introduction to the I-IoT platform and architectures, OSGi, micro-service and server less computing.

Module IV:
Internet of Medical Things Introduction and system architecture: Introduction, IoMT Devices-On-Body Devices, InHome Devices, Community Devices, In-Clinic Devices, InHospital Devices, IoMT System Architecture-Data Collection Layer, Data Management Layer, Medical Server Layer.

Module V:
Internet of Medical Things Security Threats, Security Challenges and Potential Solutions: IoMT Attack Types, Challenges in IoMT Security Schemes, Current Security Plans for

IoMT, Potential Solutions for Security Vulnerabilities, Core differences between IoT and IoMT – purpose and application, regulatory compliance.

Text Books:

1. Veneri, Giacomo, and Antonio Capasso- Hands-on Industrial Internet of Things: Create a Powerful Industrial IoT Infrastructure Using Industry 4.0, 1st Ed., Packt Publishing Ltd, 2018.
2. D. Jude Hemanth and J. Anitha George A. Tsihrintzis- Internet of Medical Things Remote Healthcare Systems and Applications, covered by Scopus

Reference Books:

1. Alasdair Gilchrist- Industry 4.0: The Industrial Internet of Things, 1st Ed., Apress, 2017.
2. Reis, Catarina I., and Marisa da Silva Maximiano, eds.- Internet of Things and advanced application in Healthcare, 1st Ed., IGI Global, 2016.

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	0	0	0	3	2	0	2	3	2	1
CO2	3	2	0	2	0	3	2	0	2	3	2	3
CO3	3	2	0	0	0	3	0	0	2	3	2	3
CO4	3	2	0	2	0	3	1	0	2	3	2	3
CO5	3	3	0	2	0	3	0	0	2	2	1	2

Course Title: Statistical Signal Analysis (ECL 437)

<table>
<tr><td>Course Code:</td><td>ECL 437</td><td>Course Title:</td><td colspan="4">Statistical Signal Analysis</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Elective</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Nil</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. To understand the concept of estimation theory.
2. To understand the concept of detection theory.
3. Able to design statistical signal processing systems.
4. To design estimators for various signal processing and communication problems
5. To design a parametric model with optimal model parameters.

Course Contents:

Module 1:

Probability Theory: Review of probability, Sample space, Algebra and random variable, Distribution and densities, Characteristics functions and moment generating functions, Transformation (function) of random variables; Conditional expectation.

Module II:

Sequences of random variables: convergence of sequences of random variables, Statistical Independence, Uncorrelation of Random Variables, Joint and Marginal Densities Function of random variables.

Module III:

Stochastic processes: wide sense stationary processes, orthogonal increment processes, Wiener process, Ergodicity, Mean square continuity.

Module IV:

Stochastic Calculus: mean square derivative and mean square integral of stochastic processes.

Module V:

Stochastic systems: response of linear dynamic systems to stochastic inputs correlation function; power spectral density function; introduction to linear least square estimation, Least square and mean square error.

Text Books:

1. A. Papoulis, and S.U. Pillai, Probability Random Variables and Stochastic Processes, 4^{th} Ed., Mc Graw Hill, 2002.

Reference Book:

1. A. Larson and B.O. Schubert, Stochastic Processes, Vol. I and II, Holden-Day, 1979.
2. A.L. Gracia, Probability and Random Processes for Electrical Engineer, 3rd Ed. Pearson Education, Inc., 2008.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. To study Basics of Random Signals and Probability Analysis
2. To perform Signal Estimation
3. To perform Scalar Parameter Cramer-Rao Lower Bound
4. To perform Vector Parameter Cramer-Rao Lower Bound
5. To perform Maximum-Likelihood Estimation
6. To perform Bayesian Estimation
7. To design and perform Kalman Filtering
8. Introduction to Signal Detection
9. To detect the Deterministic Signals
10. To detect the Random Signals

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	0	3	3	0	1	0	1	0	0	1
CO2	3	3	0	3	3	0	1	0	1	1	0	1
CO3	3	3	3	3	3	0	0	0	1	2	0	1
CO4	3	3	3	3	3	0	0	0	1	2	0	1
CO5	3	3	0	3	3	1	1	0	1	1	0	1

Course Title: Computer Vision (ECL 441)

<table>
<tr><td>Course Code:</td><td>ECL 441</td><td>Course Title:</td><td colspan="4">Computer Vision</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Elective</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>NIL</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
<tr><td colspan="7">Course Outcomes:

1. Apply development flow for designing a Computer Vision system.
2. Demonstrate the ability to select and perform suitable image and video processing followed by post processing operations as required by Computer Vision system.
3. Identify suitable processing device for CV as per the application.
4. Rectify algorithmic steps to improve accuracy of Computer Vision system.
5. Manage resources for different tasks in Computer Vision system.</td></tr>
<tr><td colspan="7">Course Contents:

Module I:
Camera Geometry: Introduction, Homogenous Coordinate system, Epipolar Geometry. Camera Calibration: Monocular & Binocular Vision, Camera matrices, Camera calibration

Module II:
Depth information in binocular vision: perception of depth in binocular vision, 3D images using depth information.

Module III:
Motion Estimation: Motion estimation and compensation. Case Study: Optical flow and applications.

Module IV:
Image Features: Edge, Corners, Blob, Ridge features. Case Study: Histogram of oriented gradients (HoG).

Module V:
Learning in Computer Vision: Introduction to Machine learning, Adaboost learning (Face detection), Deep learning based object detection and recognition.</td></tr>
</table>

Text Book:

1. R. Szeliski, Computer Vision: Algorithms and Applications, 2nd Ed., Springer, 2010.

Reference Book:

1. T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning, 2nd Ed., Springer Series in Statistics, 2009.
2. D. Forsyth, and J. Ponce, Computer Vision: A Modern Approach, 2nd Ed., Pearson Education, Inc., 2012.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any) :

1. Introduction to CPU, GPU, Cloud processing in context to Computer Vision.
2. Calibrate a camera and find camera parameters and matrices.
3. Calibrate stereo camera (Binocular vision) and find stereo parameters.
4. Generate 3D point cloud using Binocular Vision i.e using two cameras.
5. Track an object by estimating its motion in video sequence
6. Develop feature extraction algorithm (ex. Histogram of Oriented Gradients)
7. Add feature information along with its motion to track an object in video sequence
8. Develop face detection algorithm (Ref. Viola Jones face detector)
9. Object detection using deep learning algorithms in python framework and libraries
10. Object recognition using deep learning algorithms in python framework and libraries

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	0	0	0	0	1	2
CO2	3	3	3	1	1	0	0	0	0	0	1	2
CO3	3	3	3	3	1	0	0	0	1	0	2	2
CO4	3	3	3	3	2	0	0	1	2	2	3	2
CO5	3	3	3	3	2	0	0	1	3	3	3	2

Course Title: Robotics (ECL 442)

<table>
<tr><td>Course Code:</td><td>ECL 442</td><td>Course Title:</td><td colspan="4">Robotics</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Departmental Elective (DE)</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>NIL</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

1. Apply knowledge of robotics for understanding, formulating and solving engineering problems.
2. Acquire knowledge and hands-on competence in applying the concepts in the design and development robots
3. Demonstrate creativeness in designing and development of robotics.
4. Identify, analyze and design of robots useful to the society.
5. Work effectively with multidisciplinary robots.

Course Contents:

Module I:

Introduction Fixed & flexible automation, evolution of robots and robotics, laws of robotics, progressive, advancement in robots, manipulator anatomy, arm configuration & work space, human arm characteristics, design and control issues, manipulation and control, actuators, sensors and vision, programming of robots, applications – material handling, processing applications, assembly applications, inspection applications etc, the future prospects, notations.

Module II:

Coordinate Frames, Mapping and Transforms Coordinate frames, description of objects in space, transformation of vectors, inverting a homogeneous transform, fundamental rotation matrices. mechanical structure and notations, description of links and joints, kinematic modeling of the manipulator, Denavit – Hartenberg notation, kinematic relationship between adjacent links, manipulator transformation matrix.

Module III:

Kinematic Modeling of Robots Position analysis - direct and inverse kinematic models of robotic manipulators, various examples. velocity analysis – Jacobian matrix, introduction to inverse kinematic model.

Module IV:

Robotic Sensors and Vision Introduction regarding sensing technologies, sensors in robotics, classification, characteristics, internal sensors – position, velocity, acceleration sensors, force sensors, external sensors – proximity, touch and slip sensors. robotic vision, process of

imaging, architecture of robotic vision systems, image acquisition, components of vision system, image representation, image processing.

Module V:

Motion Planning and Control of Robot Manipulators Trajectory planning of robotic manipulator: joint space and Cartesian space techniques. open and close loop control, linear control schemes, examples of control models. Robot applications Industrial applications, material handling, processing applications, assembly applications, inspection application, principles for robot application and application planning, justification of robots, robot safety, non-industrial applications, robotic application for sustainable development.

Text Books:

1. R.K. Mittal & I.J. Nagrath, Robotics and Control, 1st Ed.,T MH Publications, 2003.
2. Saced B. Niku, Introduction to Robotics Analysis, Systems Applications, Pearson Publications, 2001.

Reference Books:

1. Howie Choset , Principles Of Robot Motion, Theory, Algorithms and Implementations, MIT Press, 2005
2. R.S.Hartenberg and J. Denavit Kinematics and Synthesis of linkages, McGraw Hill, 1964.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Introduction to CPU, GPU, Cloud processing in context to Computer Vision.
2. Calibrate a camera and find camera parameters and matrices.
3. Calibrate stereo camera (Binocular vision) and find stereo parameters.
4. Generate 3D point cloud using Binocular Vision i.e using two cameras.
5. Track an object by estimating its motion in video sequence
6. Develop feature extraction algorithm (ex. Histogram of Oriented Gradients)
7. Add feature information along with its motion to track an object in video sequence
8. Develop face detection algorithm (Ref. Viola Jones face detector)
9. Object detection using deep learning algorithms in python framework and libraries
10. Object recognition using deep learning algorithms in python framework and libraries

Course Title: Real Time Operating Systems (ECL 458)

<table>
<tr><td>Course Code:</td><td>ECL 458</td><td>Course Title:</td><td colspan="4">Real Time Operating Systems (RTOS)</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Elective</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Computer Architecture and Organization, Embedded systems</td><td>Type of Course</td><td colspan="4">Electronics and Communications Engineering</td></tr>
</table>

Course Outcomes:

1. Understanding the features of operating systems.
2. Understanding different scheduling approaches of real time systems.
3. Developing the ability to create the real time systems.
4. Implementation of real time system using ARM processor.
5. Developing embedded multitasking application.

Course Contents:

Module I:
Introduction to Operating Systems: Introduction of operating systems, OS structures, types of operating systems, Memory management systems, I/O systems.

Module II:
Introduction to real time computing: Basic structure of a real time system, Characteristics of real time systems - Hard and Soft real time systems, Design Challenges - Performance metrics - Prediction of Execution Time: Source code analysis, IDE and Programming Languages for Real-Time Systems.

Module III:
Scheduling Mechanisms: Understanding Task allocation algorithms - Single-processor and Multiprocessor task scheduling - Clock-driven and priority-based scheduling algorithms- Fault tolerant scheduling.

Module IV:
Case Study: ARM (Cortex- M) [FreeRTOs]

Module V:
Implementation of real time system using ARM controller or simulator.

Text Book:

1. Jane W. S. Liu: Real-Time Systems, Pearson Education, 2006
2. Krishna C.M. & Shin K.G.: Real-Time Systems, McGraw-Hill, 2013

References Books:

1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, 7th Edition Wiley Higher Education,2005.
2. Rajib Mall: Real-Time Systems, Theory and Practice, Pearson Education, 2012.

List of Lab Assignments / Experiments OR List of Tools on which the lab assignment should be based (If Any)

1. Create an application that creates two tasks that wait on a timer whilst the main task loops.
2. Write an application that creates a task which is scheduled when a button is pressed, which illustrates the use of an event set between an ISR and a task
3. Write an application that Demonstrates the interruptible ISRs(Requires timer to have higher priority than external interrupt button)
4. Write an application to Test message queues and memory blocks.
5. Write an application to Test byte queues
6. Write an application that creates two tasks of the same priority and sets the time slice period to illustrate time slicing.
7. Sending message to PC through serial port by three different tasks on priority Basis.
8. Porting Linux and developing simple application on Xilinx Zed board
9. Developing image processing application with Linux OS on Xilinx Zynq FPGA
10. Write simple applications using RTX (ARM Keil's real time operating system, RTOS).

Program Outcomes												
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	1	1	0	0	0	0	0	0	0	2
CO2	3	3	1	1	0	0	0	0	0	0	0	2
CO3	3	3	3	1	0	0	0	0	1	1	2	2
CO4	3	2	3	3	2	0	0	0	2	2	2	2
CO5	3	2	3	3	2	0	0	0	2	2	2	3

Course Title: Fundamentals of Machine Learning (ECL 462)

Course Code:	ECL 462	**Course Title:**	Fundamentals of Machine Learning			
Category:	Elective	**Credit Assigned**	L	T	P	C
			3	0	2	4
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

1. To explore different applications of machine learning and to get acquainted with basics of ML.
2. To understand formulation of regression and non-parametric classification algorithms.
3. To understand formulation of parametric classification algorithms.
4. To understand formulation of artificial neural network.
5. To understand formulation of different unsupervised learning algorithms along with applications.

Course Contents:

Module I :
Introduction to machine learning: Terminologies, Applications, Types of learning. Performance measures of classification: Confusion matrix, Area under RoC curve. Hypothesis space, Bias and variance, Bias-variance tradeoff, K-fold cross validation.

Module II :
Linear regression, Logistic regression, Bayesian decision theory, Bayesian networks, K nearest neighbor algorithm.

Module III :
Support vector machine classifier, kernel methods. Decision Trees: Representing concepts as decision trees. Recursive induction of decision trees. Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Occam's razor. Overfitting. Ensemble classifiers: stacking, bagging, boosting. Random forest, Ada Boost algorithm.

Module IV :
Artificial Neural Networks: Neurons and biological motivation. Perceptrons, Activation functions, Multilayer perceptron network, Gradient descent and error back-propagation. Weight initialization, Regularization.

Module V :
Unsupervised learning: Gaussian mixture model and Expectation maximization (EM) algorithm. K means clustering, Agglomerative clustering, Mean shift clustering, Fuzzy K means clustering. Semi supervised learning with EM.

Text Books:

1. T. M. Mitchell, Machine Learning. New York, NY, USA: McGraw-Hill, 1997.
2. E. Alpaydin, Introduction to Machine Learning, 3rd Ed. MIT Press, Cambridge, 2014.

Reference Books:

1. C. M. Bishop, Pattern Recognition and Machine Learning. New York: Springer, 2006.
2. R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, 2nd ed. New York, NY, USA: Wiley, 2001

List of Experiments:

1) To build a good training set- Dataset preprocessing.
2) Data Compression via dimensionality reduction.
3) To implement multilayer ANN from scratch.
4) Support vector machine classification with different kernel methods using scikit learn.
5) To build a decision tree and combine multiple decision trees with random forest.
6) To combine different models for ensemble learning.
7) To perform simple and multiple linear regression.
8) To perform clustering analysis.
9) Embedding a machine learning model into a web application.
10) Case study: applying a machine learning model for sentiment analysis.

	Program Outcomes											
CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	2	2	1	1	0	1	2	0	2
CO2	3	3	2	2	3	2	2	1	1	2	2	2
CO3	3	3	2	2	3	2	2	1	1	2	2	2
CO4	3	3	3	3	3	2	2	1	2	2	2	2
CO5	3	3	3	3	3	3	2	2	3	2	3	2

B.Tech
ECE(IoT) Syllabus
Fractal Courses
IIIT Nagpur

Sr. No	Year	Semester	Course Code	Course Title	Type	L	T	P	Credits
1	3	6	ECEF01	Antenna Design and Radiation	ECE	1	0	0	1
2	3	6	ECEF02	Routing in Wireless Sensor Network	ECE	1	0	0	1
3	3	6	ECEF03	Sensor Fusion	ECE	1	0	0	1

Course Title: Antenna Design and Radiation

Course Code:	ECEF01	**Course Title:**	Antenna Design and Radiation			
Category:	Fractal Course	**Credit Assigned**	L	T	P	C
			1	0	0	1
Pre-Requisite (if Any)	Electromagnetic Field Theory (ECE 208)	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:
On successful completion of the course, students will be able to:

1) Illustrate the theory of radiation, antenna and antenna arrays.
2) Understand the antenna terminologies and their significance.
3) Design different types of antennas and explore their applications.

Course Contents:

(3 Hours): Introduction to Radiation Theory

- Overview of the theory of radiation.
- Different types and categories of antenna.
- Concept of antenna arrays and types of arrays like broadside, end-fire, conformal, etc.

(2 Hours): Antenna fundamentals and Terminologies

- Antenna terminology: Gain, Aperture, Radiation intensity, Directivity, Directive gain, Beam
- width, Radiation patterns, FBR, Antenna bandwidth etc.
- Understanding of antenna measurement methods.
- Analysis of power patterns of various antennas

(7 Hours): Antenna Design

- Design of Wired Antennas like Dipole, Monopole, Yagi Uda.
- Design of Microstrip patch antennas.
- Design of antenna for different Industrial applications having characteristics like Wideband, circularly polarized, High gain, etc
- Case studies of different antenna applications in real-world scenarios.

Text Books:

1) "Antennas and Wave Propagation", K. D. Prasad, Satya Prakashan, 2021.
2) "Electromagnetic waves and radiating systems", Edward Jhordan and Keith Balmin, Pearson Education, 2nd Edition, 2015.

Recommended Books:

1) "Antennas for all applications", John D. Kraus and Ronald J. Marhefka, McGraw-Hill Education, 2002
2) "Elements of electromagnetism", Matthew Sadiku, Oxford, 2010
3) "Electromagnetic Waves", R. Shevgaonkar, McGraw Hill Education India, 2017

CO PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	2		2								1
CO2	2					1						
CO3	3	3	3	1	2							1

Note:
3: High
2: Medium
1: Low

Course Title: Routing in Wireless Sensor Network

Course Code:	ECEF02	**Course Title:**	Routing in Wireless Sensor Network			
Category:	Fractal Course	**Credit Assigned**	L	T	P	C
			1	0	0	1
Pre-Requisite (if Any)	Nil	**Type of Course**	Electronics and Communication Engineering			

Course Outcomes:

On successful completion of the course, students will be able to:

1) Learn about the issues in the design of wireless ad hoc networks
2) Understand the working of protocols in different layers of sensor networks
3) Undestand different aspects in sensor networks

Course Contents:

Part – I :SENSOR NETWORKS – INTRODUCTION & ARCHITECTURES (4 Hours)

Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture – Hardware Components, Energy Consumption of Sensor Nodes, Network Architecture – Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.

Part - II: WSN NETWORKING CONCEPTS AND PROTOCOLS (8 Hours)

MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts – S-MAC, The Mediation Device Protocol, Contention based protocols – PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol, Routing Protocols- Energy Efficient Routing, Challenges and Issues in Transport layer protocol.

Text Books:

1) "Wireless sensor networks: technology, protocols, and applications", Sohraby, Kazem, Daniel Minoli, and Taieb Znati, John wiley & sons, 2007.

Recommended Books:

1) "Protocols and Architectures for Wireless Sensor Networks", Holger Karl, Andreas Willig, John Wiley & Sons, Inc., 2007.

CO PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	2	3		2						2		
CO2	3	1		2	2					1		1
CO3	3	2	1	1	2		1					

Note:

3: High

2: Medium

1: Low

Course Title: Sensor Fusion

<table>
<tr><td>Course Code:</td><td>ECEF03</td><td>Course Title:</td><td colspan="4">Sensor Fusion</td></tr>
<tr><td rowspan="2">Category:</td><td rowspan="2">Fractal Course</td><td rowspan="2">Credit Assigned</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Pre-Requisite (if Any)</td><td>Nil</td><td>Type of Course</td><td colspan="4">Electronics and Communication Engineering</td></tr>
</table>

Course Outcomes:

On successful completion of the course, students will be able to:

1) Recognize the need of sensor fusion.
2) Understand the filter variables for the sensor fusion.
3) Able to design the filter as per need of the system.

Course Contents:

(4 Hours): Introduction to Sensor Fusion

- Overview of Sensor Fusion
- Need of Sensor Fusion and ways to do it.
- Introduction to complementary filters
- g-h Filter intuition and design.

(4 Hours): Kalman Filter

- Introduction and types of Kalman Filter
- Understanding State matrices, variance, co-variance and Kalman gain.
- Formulation and Design of Kalman Filter.
- Design of Kalman filter for sensor fusion (Accelerometer, Magnetometer and Gyroscope data)

(4 Hours): Advance Complementary filters

- Extended Kalman Filter
- Unscented Kalman Filter (UKF)
- Particle Filter
- Bayesian Filter

Text Books:

1) “Kalman and Bayesian Filters in Python”, Roger R Labbe Jr, 2018

Recommended Books:

1) "An Introduction to the Kalman Filter.", Greg Welch, Gary Bishop, 2001. *https://www.cs.unc.edu/~welch/media/pdf/kalman_intro.pdf*

CO PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	2		2								
CO2	3	2	2	1								1
CO3	3	3	3		2				1			1

Note:
3: High
2: Medium
1: Low